Learning and Labor.
LIBRARY
OF THE
University of Illinois.
CLASS BOOK. VOLUME.
631.3 J65
Accession No.

THE MODE

OF

DRAINING LAND,

ACCORDING TO THE SYSTEM PRACTISED BY THE LATE

MR. JOSEPH ELKINGTON.

DRAWN UP FOR THE CONSIDERATION OF

THE BOARD OF AGRICULTURE,

By JOHN JOHNSTONE,

LAND-SURVEYOR.

WITH NINETEEN PLATES.

LIBRARY

A NEW EDITION.

HUMIDIOREM AGRUM FOSSIS CONCIDI ATQUE SICCARI,
UTILISSIMUM EST.——— PLIN. NAT. HIST.

LONDON:

M. TAYLOR, 1 WELLINGTON STREET STRAND.

(REMOVED FROM HIGH HOLBORN.)

1841.

[*Entered in Stationers' Hall.*]

LONDON:
PRINTED BY MOYES AND BARCLAY, CASTLE STREET, LEICESTER SQUARE.

UNIVERSITY OF ILLINOIS
AGRICULTURE LIBRARY

631.3
J65

UNIVERSITY OF ILLINOIS LIBRARY

INTRODUCTION.

Of all the arts that have excited the attention, or called forth the exertions of mankind, none has been discovered so valuable, or so generally useful, as *Agriculture;* not only by rewarding the skill and industry of the individual, but by exalting the prosperity of a nation.

It is, undoubtedly, the most ancient, and the foundation on which all other arts depend; a foundation every day becoming stronger and more respectable, by acquiring support and encouragement from the first characters in this kingdom. Having now attained that degree of respectability which its nature and utility, as a great national object, deserve, it cannot fail of exciting a very general attention to the practice of it; a practice by which the permanent interests of the kingdom may be so much advanced. Agricultural pursuits are, of all others, the most conducive to health and vigour. The study, or theory of it, enlarges the intellectual, and its practice employs in useful exercise the active, powers of man. By much the greatest part of this island, both with regard to soil and climate, is very favourable to Agriculture, and capable of much improvement; the means of which are almost every where at hand. It is not, however, the intention of this Treatise to shew what are the general improvements connected with Agriculture, but to explain and describe that branch of it alone which may not only be reckoned the most important, but one upon the practice of which most of the others, in certain situations, depend. It is surprising that

981

so few attempts have been made to reclaim and improve some of the many extensive tracts of *wet boggy land*, that are every where to be met with in this country; which, in the language of a late writer,* are "at present a reproach to the age, a disgrace to the country, and a nuisance to the occupiers."† In point of local advantages, land of this description has a preference to every other kind of waste ground, by being more productive when improved, and often lying in situations more sheltered, and accessible to improvement, than many parts of barren land, which, although dry, are in other respects less favourable to cultivation. Draining is the first step towards the improvement of these, as well as of every other species of wet land. It is in every respect the most essential method by which their improvement or cultivation can be accomplished; and, when executed with judgment, the advantages derived from it are not only immediate, but sure and permanent. If land be in tillage, and remain wet, every manure that can be applied to it loses its effect, and fails to produce so abundant a crop as a much less quantity would yield, were the land dry. If in pasture, the grass it produces is of a coarse unhealthy nature, fit neither for feeding of stock nor for being converted into hay. In sheep-walks the bad effects of wetness are often severely felt. The rot, that destructive malady among sheep, chiefly proceeds from the nature of the herbage, which too much noxious moisture produces; and as it is a disease hitherto deemed incurable, it can only be *prevented* by means of Draining.

* Mr. Boswell on Water Meadows.

† In an Address by the President to the Board of Agriculture, on the Cultivation and Improvement of the Waste Lands of Great Britain, printed in December 1795, he says,—"A considerable proportion of the Wastes of Great Britain consists of lands of a wet and boggy nature, which, it has been yet supposed, was the most difficult to improve and cultivate. Fortunately, however, discoveries have been made in the art of draining such bogs, by Mr. Joseph Elkington, a farmer of the county of Warwick, as renders the improvement of swampy land a matter of much less difficulty or expense than formerly."

The effects of Draining, on the climate, are also considerable. In hot weather the exhalations that arise from large tracts of moss and marshy ground must increase the humidity of the climate, and render it unsalubrious to the inhabitants, as well as injurious both to animal and vegetable life: hence, in such situations, animals are unhealthy, and every kind of grain is longer in coming to maturity; its harvest precarious, and the quality of its produce inferior; occasioned by the dampness of the soil and impurity of the atmosphere.

The Draining of one large tract of land may furnish water for the accommodation of another; which, if collected in sufficient quantities, may be converted to its improvement by irrigation. By the same means a more abundant and regular supply of water may be obtained to drive mills, and other machinery constructed for various purposes, and for supplying canals, or artificial navigations, houses, fish-ponds, inclosures, &c. It may also be applied, with great advantage, in the case of mines, by diminishing the quantity of water found in working them, as shall afterwards be shewn.

Digitized by the Internet Archive
in 2017 with funding from
University of Illinois Urbana-Champaign Alternates

https://archive.org/details/modeofdrainingla00john

UNIVERSITY OF ILLINOIS
AGRICULTURE LIBRARY

ADVERTISEMENT.

The Board of Agriculture had hardly been established before it received intelligence, from various parts of England, of the singular success with which Mr. Joseph Elkington, a Warwickshire farmer, practised the art of draining land, the publication or discovery of which was represented to be one of the greatest means of promoting the improvement of this country that could be suggested. It is unnecessary to trace the various steps taken by the Board for attaining so important an object. It may be sufficient to mention, that in consequence of a motion made by its President on the 10th of June, 1795, the House of Commons voted an Address, "That His Majesty would be graciously pleased to give directions for issuing to Mr. Joseph Elkington, as an inducement to discover his mode of draining, such sum as His Majesty in his wisdom shall think proper, not exceed-

ing the sum of 1000*l.* sterling; and to assure His Majesty that this House will make good the same to His Majesty."

Mr. Elkington's health being extremely precarious, there was a risk that the public might lose the benefit of the knowledge he had acquired, by the experience of above thirty years, in a species of improvement which, in these kingdoms, ought to be considered as the basis of every other. To prevent so unfortunate a circumstance, the Board resolved to send Mr. John Johnstone, to visit, in company with Mr. Elkington, the principal Drainages he was executing, and to take drawings thereof. It is to be hoped that the following Report, the result of that journey, with the annexed views and sections, will furnish the reader with very satisfactory information upon the subject of this art, and will sufficiently explain the various modes of draining land, whether practised by Mr. Elkington, or others.

UNIVERSITY OF ILLINOIS
AGRICULTURE LIBRARY

UNIVERSITY OF
LIBRARY
ILLINOIS

PREFACE.

THE writer having, by appointment of the Board of Agriculture, and of the Highland Society of Scotland, accompanied Mr. Elkington on a survey through those counties of England where he was executing the most remarkable Drainages at that time (in summer 1796), for the purpose of acquiring a knowledge of his art, and having thus had an opportunity of seeing the operation carried on in all its stages, he hopes the following pages will be found to contain the fullest and most correct narrative of that useful discovery hitherto laid before the public,—a discovery by which many thousand acres of the southern part of this island have been already so much improved.

When the writer has ventured to propose any thing new, or that does not come within the bounds of Mr. Elkington's practice, he has done so, not with a view of recommending *his own* but from a desire of giving hints that may be useful to others. The observations he has ventured to suggest with regard to the importance of the object he is describing, and the *real* advantages to be derived from Mr. Elking-

ton's mode of draining, he has endeavoured to establish, by authentic quotations from the Agricultural Reports of those counties in England where these advantages are taken notice of, and from other satisfactory sources of information.

It cannot be expected that he is to enter into a learned disquisition on the nature of springs, a physical inquiry into the cause and formation of bogs, or into a chemical examination of the qualities of soil; these are researches that come not within the limits of his knowledge, although in some degree connected with the subject. He will content himself with briefly stating facts, so far as to explain the principles of the art, and will endeavour to convey its meaning in the best language he can, so far as the nature of the subject will admit. Where he has used provincial words, which are almost unavoidable in a georgical treatise of this kind, he has done so because they are the terms of expression commonly applied; but he has also added such explanation as will render their meaning generally understood.

Being aware that without the help of explanatory sketches it would have been impossible to convey a just idea of the nature and principles upon which the system is founded, he has, therefore, given such Plans of the various situations, and Sections representing the inclination of those internal strata that produce springs and wetness in ground, as he hopes

will be useful in facilitating the acquirement of that knowledge. The origin of this discovery he has thought proper to explain, which, although immaterial in itself, may serve as a proof of the circumstances that first led Mr. Elkington to a knowledge of the art.

To the drainage of bogs, and other wet ground caused by springs, he has confined the subject of this report, more than to that of soils that are injured only by rain-water stagnating on the surface; the former being a branch of the system that has hitherto been less known or attended to, and as the latter is a part of it more generally understood, and not so much the object of Mr. Elkington's practice.

The mode, however, of draining some soils, the wetness of which does not proceed from continual springs, and where the auger is seldom applied, he has endeavoured to point out, in a manner whereby it may be accomplished by means of much less cutting and expense than what has formerly been practised. He has also, in the second part of the work, given a particular description of all the different modes of hollow and surface-draining, as more especially practised in the eastern counties of England; and, in the Appendix, has offered hints which he hopes may be useful in directing the *further improvement* of bogs, &c. after being drained.

As the former edition of this work was written

under circumstances not so favourable to perspicuity and detail, it is now offered to the review of the public with such corrections and additions as the writer's practice and experience have enabled him to make, and which he hopes will render it more useful. The plates have likewise been revised, and, for the sake of further illustration, several new ones have been added, and the whole is now arranged in a better manner.

To the Board of Agriculture, &c. it is humbly offered, with a view to facilitate the acquisition of this useful art; and if, through its means, a desire to prosecute the improvement it recommends should be excited, the writer will feel a satisfaction by having, in some degree, contributed to establish that important object, hoping that, by the influence of that honourable Board, and of the Society under whose patronage he attended Mr. Elkington, the knowledge of it will be so much extended as to render the practice of it general in every situation where it may be applied with advantage.

When it comes into the hands of some of those intelligent gentlemen who have seen, and are acquainted with, the nature and method of Mr. Elkington's system, the writer hopes they will pass over any imperfections that this account may contain, and will not hesitate to correct its errors or to supply its defects.

CONTENTS.

PAGE

INTRODUCTION iii

PART I.

CHAP. I.—An Account of the Origin of the Discovery, and Means that first led Mr. Elkington to a Knowledge of the Art 1

CHAP. II.—On the Principles of Mr. Elkington's Mode of Draining 5

CHAP. III.—Drainage of Bogs, and other Wet Ground caused by Springs 9

CHAP. IV.—Drainage of Hills and Sheep-Pastures, with Observations on the Means of Procuring and Raising Water for Wells, &c. 25

CHAP. V.—Drainage of Bogs, and other Wet Ground, by Perforating through a Retentive to a Porous Substratum 30

CHAP. VI.—Drainage of Soils composed of alternate Beds of Clay and Sand 39

CHAP. VII.—Drainage of Soils Porous above, and Retentive Below, &c. 43

CHAP. VIII.—Drainage of Ground lying along the Side of Rivers, and artificial Leads of Water 46

CHAP. IX.—Drainage of Mines, Quarries, Marl Pits, &c. .. 49

CHAP. X.—Observations on the Use of the Spirit-Level, and Directions for Using it in Marking Out of Drains 55

CHAP. XI.—Description of the Auger, and Manner of Using it, &c. 58

CHAP. XII.—Extracts from some of the Agricultural Reports of those Counties in England where Mr. Elkington has executed the most remarkable Drainages, &c., tending to authenticate the Advantages derived from his Practice .. 62

PART II.

OBSERVATIONS ON HOLLOW AND SURFACE-DRAINING IN GENERAL.

PAGE

Introduction 71

Sect. I.—Antiquity of the Practice of Hollow-Draining .. 72

Sect. II.—When first used in England 73

Sect. III.—Nature of the Moisture, or Wetness, against which they are chiefly used 74

Sect. IV.—Of the Soils on which they act, and of those on which they have been found to fail ..... *ibid.*

Sect. V.—By what Rules their Direction is marked..... 76

Sect. VI.—Season for Executing the Work 77

Sect. VII.—Manner in which Drains are partly opened by the Plough 79

Sect. VIII.—Depth and Width 80

Sect. IX.—Tools employed 81

Sect. X.—Of Digging Hollow Drains ..... *ibid.*

Sect. XI.—Opening Drains by the Plough only. 82

Sect. XII.—Materials with which they are filled 84

Sect. XIII.—Mode of Filling 88

Sect. XIV.—Of the Expense 89

Sect. XV.—Of Sod, or Pipe-Drains. 90

Sect. XVI.—Duration of Covered Drains 93

Sect. XVII.—Drainage of Stiff and Retentive Soils by open Cuts, and the Proper Formation of Ridge and Furrow .. 94

Sect. XVIII.—Mode of Draining Clay Soils, practised by Sir Henry Fletcher, Bart. a Member of the Board of Agriculture 98

Sect. XIX.—Of Open Drains..... 100

Sect. XX.—Of the Benefit derived from the Practice of Draining in General..... 102

APPENDIX.

Hints for the Improvement of Bogs, &c. after being Drained 107

Conclusion 118

UNIVERSITY OF ILLINOIS
AGRICULTURE LIBRARY.

UNIVERSITY OF
LIBRARY
ILLINOIS.

AN ACCOUNT

OF THE

MOST APPROVED MODE

OF

DRAINING LAND,

&c. &c.

PART I.

CHAPTER I.

ORIGIN OF THE DISCOVERY MADE BY MR. ELKINGTON, AND THE MEANS THAT FIRST LED HIM TO A KNOWLEDGE OF THE ART.

The reason for introducing the subject of this chapter has been stated in the Preface. It may be necessary to add, that the annexed plan was taken *on the spot*, in presence of Mr. Elkington, for the purpose of ascertaining the nature of the original discovery; and the explanation and information relating to it having been also received from Mr. Elkington *there*, and from others of respectability in that neighbourhood, the veracity of it may be depended on. In the year 1763 Mr. Elkington was left, by his father, the possession of a farm called Princethorp, in the parish of Stretton-upon-Dunsmore, and county of Warwick. The soil of this farm was very poor, and in many places so extremely wet, that it had been the cause of rotting several hundred sheep; which was the first means that determined him, if possible, to drain it, which he began to do in 1764.* The field in which he

* After the drainage of this field was completed, Mr. Elkington's flock was never afterwards affected with that disease.

began was of a wet clay soil, rendered almost a swamp (and, indeed, in some places, a *shaking bog*), by the springs issuing from a bank of gravel and sand adjoining it, and overflowing the surface of the clay in the manner described in the annexed plan, which is a true representation of it. In order to drain this field, he cut a trench about four or five feet deep a little below the upper side of the bog, or where the wetness began to make its appearance; and after proceeding with it so far in this direction, and at this depth, he found it did not reach *the main body of subjacent water*, from whence the evil proceeded. On discovering this, Mr. Elkington was at a loss how to proceed. At this time, while he was considering what was next to be done, one of his servants accidentally came to the field where the drain was making, with an iron crow, or bar, which the farmers in that country use in making holes for fixing their sheep-hurdles. Mr. Elkington, having a suspicion that his drain was not deep enough, and a desire to know what kind of strata lay under the bottom of it, took the iron bar from the servant, and after having forced it down about four feet below the bottom of the trench, on pulling it out, to his astonishment, a great quantity of water burst up through the hole he had thus made, and ran down the drain. This at once led him to the knowledge of wetness being often produced by water confined farther below the surface of the ground than it was possible for the usual depth of drains to reach, and induced him to think of applying an auger, as a proper instrument in such cases. Thus did the discovery originate from chance, the parent of many other useful arts! Fortunate it is for society, when such accidents happen to persons who have sense and judgment to avail themselves of the hints thus fortuitously given! In this manner he not only accomplished the drainage of this field, which soon rendered it completely sound, but likewise all the other wet ground on his farm.

The success of this experiment soon extended Mr. Elkington's fame, in the knowledge of draining, from one part of the country to another; and after having drained several farms in his neighbourhood with equal success, he at last came to be very generally employed; has been since, and is now, in various parts of the kingdom, which shall be more particularly taken notice of in the sequel. It is, indeed, now

impossible for him to execute half the employment he has in hand, or to accept the numerous offers that are every day made to him. From his long practice and experience, he is now so successful in the works which he undertakes, and also in judging of the internal strata of the earth and nature of springs, that he can, with remarkable precision, judge where to find water, and where to trace the course of springs that make no appearance on the surface of the ground. The rules on which he acts, with regard to these discoveries, will be afterwards explained, in treating of the nature of wet ground caused by springs.

Lastly, Within these few years past, since his practice has been so widely extended, and so generally successful, he has drained in various parts of England, particularly in the midland counties, many thousand acres of land; which, from being originally of little or no value, are now as productive as any in the kingdom, capable of producing the most valuable kinds of grain, or of feeding the best and healthiest species of stock.

Some have erroneously entertained an idea that Mr. Elkington's sole skill lies in applying the auger for the *tapping of springs*, without attaching any merit to his method of conducting the drains. The accidental circumstance above stated gave him the first notion of using an auger, and directed his attention to the practice of draining; in the course of which he has made various useful discoveries, which are herein afterwards more fully explained. It will be sufficient here to remark, that draining, according to his principles, depends upon three points: — 1st. Upon finding out the *main spring*, or cause of the mischief; without which nothing effectual can be done. 2d. Upon taking the level of that spring, and ascertaining *its subterraneous bearings;* a measure never practised by any, till Mr. Elkington discovered the advantage to be derived from it; for, if the drain is cut a yard beyond *the line of the spring*, you can never reach the water that issues from it; and, by ascertaining that line, by means of levelling, you can cut off the spring effectually, and consequently drain the land in the cheapest and most eligible manner. The manner in which this is done will be afterwards described. And 3dly. By

making use of the auger to reach or *tap* the spring, when the depth of the drain is not sufficient for that purpose.

In regard to the use of the auger, though there is every reason to believe Mr. Elkington was led to employ that instrument from the accidental circumstance stated above, and did not derive it from any other channel; yet there is no doubt that others have hit upon the same idea, without being indebted for it to him. It is said, that in attempting to discover mines by means of an auger, springs have been tapped, and the adjacent wet ground thereby drained, either by letting the water down, or giving it vent to the surface. The auger has also been made use of in bringing water into wells, by boring in the bottom of them, to save the expense of digging, especially in Italy, where it is probable that the practice is very ancient. But *that it has been used in draining land, before Mr. Elkington made that discovery, no one has ventured to assert.*

In Dr. Nugent's "Travels through Germany," printed anno 1768 (of which an extract will be found in Chapter V.), there is an account of a mode of draining land, on principles, in some respects, of a similar nature; not, indeed, by the use of the auger, but by making pits; and in a publication by Dr. James Anderson, entitled "Essays on Agriculture and Rural Affairs," printed anno 1775, after describing a mode of tapping the Doctor had adopted, by sinking small pits, he adds: "I have often imagined that the expense of digging these pits might be saved, by boring a hole through this solid stratum of clay, with a wimble made on purpose; but as I have never experienced this, I cannot say whether it would answer the desired end exactly."

Mr. Elkington, however, made use of the auger prior to the date of these publications, or to any hint he could possibly derive from any publication in the English language; though it is probable that, in so far as regarded *tapping of springs for wells*, the use of the auger was well known in some parts of Italy. Buffon states, "that, in the city of Modena, and four miles round, whatever part is dug, when we reach the depth of sixty-three feet, and bore five feet deeper with an auger, the water springs out with such force, that the well is filled in a very short space of time. This

water flows continually, and neither diminishes nor increases by the rain or drought."— Mentioning the different strata that are met with to this depth, he adds: "These successive beds of fenny or marshy earth and chalk are always found in the same order, wherever we dig; and very often the auger meets with large trunks of trees, which it bores through, but which give great trouble to the workmen: bones, coals, flint, and pieces of iron, are also found. Ramazzini, who relates these facts," &c.— BUFFON's *Nat. Hist.*

CHAPTER II.

ON THE PRINCIPLES OF MR. ELKINGTON'S MODE OF DRAINING.

IT is remarkable that the principles on which the draining of land depends, being so great a desideratum in agriculture, should have been so little known or attended to; or that the practice of it, according to these obvious principles, should have been so much confined, while improvements in the other branches of husbandry have been carried almost to the highest possible perfection.

However intricate or abstruse it may hitherto have been considered, even by those who were otherwise well informed in the theory of agriculture, of which it forms the most important branch; yet it will appear, from the following observations, to be founded on circumstances the most plain and rational, and which, when reduced to practice, produce those effects which a simple knowledge of the cause naturally points out.

Wetness in land proceeds from two causes, as different in themselves as the effects which they produce.

It proceeds either from rain-water stagnant on the surface, or from the water of springs issuing over, or confined under it. On clay soils, that have no natural descent, wetness is commonly produced by the first of these causes; but, in a variety of situations, it may proceed from the latter.*— But,

* Wetness of land is sometimes occasioned by the stagnation of water in the surrounding ditches, or some adjoining hollow, where, for want of declivity in the former, and owing to the higher situation of the latter, it oozes out upon the

The principles of Mr. Elkington's art are so closely connected with the nature of springs, that, without a knowledge of these, and the causes producing them, it is impossible to practise it either with success or advantage; for *surface draining*, where the wetness proceeds from subjacent water, is only alleviating the effect, in place of removing the cause. It will therefore be necessary, in the *first* place, so far to ascertain the nature of springs, and their connexion with the formation of bogs, as to enable the practical drainer more easily to comprehend the theoretical part of Mr. Elkington's system.

From its general external appearance, and by the perforations that have been made in it by quarries, wells, and other subterraneous pits, the earth is known to be composed of various strata, which, being in their nature of opposite consistence, are distinguished by the names of *porous* and *impervious*. Those strata, which, from their more open composition, are porous, and capable of receiving the rain-water that falls upon them, include rock, gravel, sand, and such marls as are of an absorbent quality. Clay, and a certain kind of gravel having a proportion of clay in its composition, which, by binding and cementing the small stones together, render it equally close and tenacious as clay itself; with such rock as is of a close and compact nature, without any fissures in it, are the principal strata that most resist the reception of water, and that are capable of retaining it on their surface till exhaled by the sun, or carried off by suitable drains, and are termed impervious.

Springs, therefore, originate from rain-water falling upon such porous and absorbent surfaces, and subsiding downwards through such, till, in its passage, it meets a body of clay or other impenetrable substance, which obstructs its farther descent; and here, forming a reservoir or considerable collection of water, it is forced either to filtrate along such body, or rise to some part of the surface, where it oozes out in all those different appearances that are so frequently met with. This is evident from the immediate disappearance of the rain-

lower ground, and finds its way into the open parts of the soil. This is frequently the case where water is conveyed in a lead, or artificial channel, the land lying lower and adjoining to it being very often wet from that cause. The remedy for these kinds of wetness is simple, and points out itself.

water, as it falls, on some parts of the ground, while it remains stagnant on others, till carried off by evaporation; and from the strength of springs being greater in wet than in dry seasons. Hence after incessant rains, they are observed to break out in higher situations, and, as the weather becomes drier, give over running out, unless at their lowest outlets. The strength of springs also, or quantity of water which they issue, depends chiefly on the extent of high ground that receives and retains the rain, forming large reservoirs, which affords them a more regular supply. Thus, bog-springs, or those that rise in valleys and low situations, are much stronger, and have a more regular discharge, than those which break out on higher ground, or on the sides of hills.

Independent of these causes, there are certainly great springs contained in the bowels of the earth; otherwise, how could the many rivers that intersect it be supplied with such vast quantities of water as they discharge, the rains falling on its surface, or the dews that descend, not being adequate for that purpose? But, as this may be considered among those arcana of Nature which have not yet been sufficiently explored, and lying at too great a depth to affect the surface, it comes not within the limits of the present inquiry.

With the nature and causes of springs, that of bogs is intimately connected; for where springs breaking out in the manner above described, run over a flat surface of clay, and cannot get off with sufficient rapidity, or are not confined to a narrow channel, the superabundance of water must cause the dissolution of all the coarse vegetables it produces, which, together with part of the natural soil itself, is formed into a peat earth, every year increasing in depth; and the extent of such bog or morass, is according to the quantity of water, and to that of the flat ground on which it is formed.* The great object of Mr. Elkington's system, is that of draining

* Many and various are the conjectures respecting the origin of peat bogs; into the merits of which it would be needless to inquire. Some suppose them to have been formed at the time of the general deluge, from the huge trees that are found in them, and from a variety of other circumstances that lead to that supposition: but it is not so much the subject of this treatise to explain their probable origin, as the means by which springs or other accumulated water may be most easily cut off, from preserving them in their present unproductive state.

such bogs, by cutting off entirely the source of the springs or subterraneous water that causes the wetness, either by flowing over the surface, or by its being long confined under it. If the springs have a natural outlet, the object of the drain is to lower and enlarge it; which, by giving the water a more free and easy channel, will sooner discharge and draw it off, or will reduce it to a level so far below the surface as to prevent its overflowing it.

Where the springs have no apparent outlet, but are either confined so far below the surface as to injure it by constant moisture, or by oozing out imperceptibly through any small pores of the upper soil; the object of the drain is, to give a proper vent to that water, and to extract more quickly and more effectually what has before been pent up in the bosom of the soil. The object of the auger, which, in many instances, is the *sine quâ non* of the business, is simply to reach or *tap* the spring, and to give vent to the water thus pent up when the depth of the drain does not reach it, where the level of the outlet will not admit its being cut to that depth, and where the expense of cutting so deep would be very great, and the execution of it very difficult.

According to these principles, this system of draining has been attended with extraordinary consequences in the course of Mr. Elkington's practice, which shall be more fully explained in the after-part of this Report. By it, not only the land in the immediate vicinity of the drain, but also springs, wells, and wet ground at a considerable distance, have been made dry, with which there was no apparent communication.

As the whole depends upon the situation of the ground to be drained, and the nature and inclination of the strata of which the adjacent country is composed; as much knowledge as possible must be obtained of these, before the proper course of a drain can be ascertained, or any specific rules given for its direction or execution. But all these circumstances will be more particularly explained in describing the parts of the operation with which they are connected.

CHAPTER III.

DRAINAGE OF BOGS, AND OTHER WET GROUND CAUSED BY SPRINGS.

The draining of extensive bogs, or tracts of marshy ground injured by springs, is a part of the system deserving greater attention than any other, and is in every point of view the most important; because many extensive tracts of ground of this description are at present lost to every useful purpose to which they might be converted, from the mistaken notion of those to whom they belong, that their nature is such as to render them incapable of being drained. But however impracticable the drainage of such bogs may appear, yet, by attention to Mr. Elkington's mode, they are not only easily drained, and at little expense, but, when they are made dry, are by far the most valuable of any. The cause and formation of these bogs have been pointed out in the preceding Chapter. They may be divided into two classes, according to their situation, and the different methods of draining them. Those of the first class are easily distinguished by the springs rising out of the adjoining higher ground, in a regular line along the upper side of the wet surface; which, together with the proper line of the drain, are delineated on the annexed Plan (Class 1st). The second class of *spring bogs** have the appearance of being still more difficult to reclaim, although, in several respects, they are less so than the former.

In these, the many springs that appear are not confined to one regular direction along the upper side, but burst out promiscuously over the whole surface (especially towards the lower side), forming quagmires that shake all around, and bend under foot like a suspended cloth, over which it is dangerous for the lightest cattle to pass, and which show themselves at a distance, by the verdure of the grass which the *quags*, or spots immediately round the springs, produce. Of this luxuriant grass, sheep are remarkably fond, and, devouring it greedily, never fail being attacked with that incur-

* So called, in contradistinction to those grounds that are wet and boggy, by retaining surface-water; and also to such *peat bogs*, or mosses, that do not originate from springs.

able disease, the rot. This is mentioned the more particularly, not only as a sufficient motive to recommend their drainage in sheep-walks, but (as has already been noticed) being one of the principal causes that first induced Mr. Elkington to attempt the drainage of a similar bog, in which he fortunately made that discovery which was the basis of his future practice. Under the peat earth, that for ten or more feet forms the upper part of these bogs, is found a bed of clay, seldom of great depth, and under that a stratum of sand, gravel, or rock, if the adjacent eminences be composed of such. The clay bed immediately above and between this and the peat, being in many places very thin, and in some degree porous, the constant pressure of water contained in the high grounds above, forces that under the bog, with which it is connected, through these more porous parts of the clay and peat, where it bursts up, forming those appearances just mentioned; which, together with the situation and course of the drain, are more clearly elucidated by the Plan (Class 2d). Such are the general appearances that distinguish these two classes of bogs; but there is a variety of wet ground injured by springs, which neither being so extensive, nor so much inclined to *peat,* to these the term *bog* * cannot so properly be applied; but, with regard to the mode of draining them, the same directions are equally applicable.

As there are a variety of circumstances that lead to a discovery of the proper line of the springs, and that must guide the direction of the trenches in draining these bogs, as well as every other description of wet ground proceeding from the same cause; it will be proper to arrange them in the order in which they follow, previous to the execution of the work.

The first thing to be observed is, carefully to examine the adjoining high grounds, in order to discover what strata they are composed of, and also to ascertain as nearly as possible, the inclination of these strata, and their connexion with the ground to be drained; and to judge at what place the level of the *same spring* comes nearest to that where the water can be discharged. By this means the length of cutting, and in

* Bog, properly signifies a quagmire covered with grass; in which sense, it differs from moss, the latter being covered with heath, and very often having no verdure at all on the surface: the greater abundance of springs in the former, also constitute a material difference in their nature.

some measure the quantity of water that the drain will issue, if it be wanted for any particular purpose, may be nearly ascertained; for, the greater the extent of the high ground contiguous to the bog, the more constant and more abundant will be the discharge; and if only a small hill or narrow bank, little water can be expected to run from it in dry seasons, when the porous strata can receive no supply from the rains.

The surest way of ascertaining the inclination and *lye* of the different strata, is by examining the bed of the nearest rivers, and the sides of the banks cut through by them, and any pits, wells, or quarries that may have been dug in the neighbourhood. Rushes and other coarse aquatics* appearing on the surface, may facilitate the investigation; but these being often produced by stagnant rain-water, where there is no spring, cannot be trusted to in cases where more minute precision is necessary.

If the resisting stratum immediately under the porous one, lie horizontally through the hill or bank, the surface below that level will be wet and rushy on both sides, and the upper side of the wet ground will be found varying very little from a level all the way round. When this is the case, which frequently happens, a drain properly conducted on the one side of the hill will carry off the water that causes the wetness on both. See Plan, No. 4.

If the resisting stratum *dip* or incline more to the one side than to the other, the springs will issue only at the lower side of that stratum; consequently the one side of the hill will be wet, and the other dry.

It is of material consequence to ascertain which of the different outlets that may appear on the surface is the main spring, or that from which these outlets are supplied; for, by cutting off that, the others become dry, and is therefore

* Small alder bushes being of the same nature as rushes, and which grow naturally only on very wet soils, are sure symptoms of the line of the springs, as they either grow up immediately over the spring or below it, seldom higher unless where the water *backs up* to, when the spring is full. The best time for ascertaining the true direction of drains, and likewise for executing the work, is, when the ground is in pasture, and has been for some time; as the rushes and other aquatics make their appearance on the wet part of the surface; or, when the ground is in fallow: the water is then seen oozing up in the furrows, along the line in which the drain should be cut, and the soil all below will retain a darker and wet appearance, when that above is dry.

one of the principal circumstances upon which the true direction of the drain depends. If, on the bank or sloping surface from whence the springs proceed, they be found to break out at different levels, according to the wetness of the season; and if those lowest down continue running while those above be dry, it is a sure sign that all the different outlets are connected with, and proceed from, the same spring, and along the level of this under one the line of the drain should be directed, which, if properly executed, all those above will afterwards continue dry. This is called the *main spring*, and those above, the overflowings of it.* If the drain was to be cut along the line of the uppermost of these outlets, and the depth of it not reaching the level of those below, the overflowings would only be carried off, the main spring still continuing to flow, and injure the ground below the bottom of the drain, having a natural vent lower. Such has been the common practice hitherto of draining ground in this situation, where Mr. Elkington's method is not understood, and which was reckoned the most effectual and most approved mode. Wherever the uppermost springs made their appearance, there a trench was cut, *between the wet and the dry*, as it is termed, which not being sufficiently deep to intercept the water, others of the same kind were cut, one below another, the whole way down the declivity; and, being filled with loose stones nearly to the top, each carried off a

* In many cases, it may be known whether the channel of the water lie deep or not, by the appearance of the surface. If the land be dry immediately above the place where the water springs up, it is an evidence that the channel or reservoir lies deep, and that the water is issuing perpendicularly; but, on the contrary, if the land be wet for some distance above the principal outlet of the spring, it is a sure sign that the water is flowing in a channel near the surface, and that it is the *overflowings* of it that causes this wetness. It would be a certain evidence of this, if there be only one spring in the wet ground; but if the internal strata do not lie horizontally or regularly, and several springs appear, arising from water running in different channels, the land above the largest or principal spring may be wet, not from the *backing up* of that spring, or its channel being near the surface, but by the breaking out of lesser springs, in their *descent*, the channel of whose waters has thus found a vent to the surface, higher than that of the larger spring. It is in cases of this kind that draining is attended with most difficulty; and where all the cutting, &c. necessary, cannot so easily be ascertained at first, till such time as what is absolutely requisite be executed: which will lead to a discovery of what more is wanted, and in what manner it should be done, by exposing to view the subsoil, or strata, in which the water flows. Making *exploratory bores* with the auger is useful in this, and in all other difficult cases.

portion of surface water only, without ever affecting the spring that caused the mischief. The consequence of such drains is, that they render the surface drier while they continue to run; but soon choking up, and bursting out in different parts, the ground soon becomes equally wet, or more so than before they were made. It is more difficult to drain this ground a second time, even in the proper manner, as the surface, by means of the former drains, being so much altered from its natural appearance, the true situation of the springs cannot so easily be hit on; and the frequent bursts of the old drains increase the perplexity.

It frequently happens that the uppermost (if the *strongest outlets*) are the *main springs*, and those below only *leakages*.*

Therefore the same caution is necessary to ascertain this, before proceeding to mark out the drain, as from the *main spring only* the level must be taken, in the manner described in Chapter IX.

In irregular banks, where the ground, owing to the perpendicular situation, or pressure of water behind, has *slipped*, or fallen down, the drain must be carried higher up the declivity than where the water has its apparent outlet, to the sound ground that has undergone no change, and where the *real spring* will be intercepted; the water in the slipped sand below, being only *leakages* from that above, but which is apt to deceive in cutting the upright trench.† When the main-spring rises in a steep bank a considerable height above the level of the brook, or place where the drain is to discharge itself, it is unnecessary to cut a deep trench, or to lay a covered drain all the way from the brook up to it; for the descent being too rapid, and if deep cut, by crossing veins of sand that are always met with in such situations, the bricks or stones with which the *sough* or conduit of the drain is laid, would be undermined by the rapidity of the current, which would also carry down a great quantity of the loose sand; but it should be begun only so far down the bank, as

* This term implies, that some of the water from the main spring finds a passage through some opening in the *upper soil* near the surface, and breaks out lower than the main spring, when it meets with resistance from any bed of clay. By cutting off the main spring, this of course becomes dry.

† The upright trench is the drain from the outlet up to the cross one, along the line of the springs.

by *cutting in level*, the drain may be six or seven feet lower than the outlet of the spring, or whatever depth is necessary for drawing down the water to such a level, as it may discharge itself without rising to the surface, or injuring the ground adjoining it. The remaining part of the cut down to the brook, either in a straight or sloping direction, may be left open, and need not be deep, but guarded from the cattle, and from the plough, when the field is in tillage. If covered, it need not be deeper than two feet; and there is no occasion for boring in any part of it. See fig. 2, and 3, plan No. 5.

If there be any difficulty in ascertaining the exact line of the spring, and that of the cross drain, *where it does not appear on the surface*, or when there is no apparent outlet from whence to take the level, in bringing up the leading drain for carrying off the water, it can be then discovered when it crosses the proper line; and, without cutting any further up, the cross drain must be carried on that level, so far to each side along the *tail*, or termination of the rock or sand containing the water, as the situation of the ground, and other circumstances, may require; and if, in cutting the cross drain, the line marked out by the spirit-level should be found in some places to be below that of the springs; and if, in boring along that line, no water be found, then small cuts must be made of the same depth, from the drain up to where the spring lies, as at the letters A in fig. 1, of plan 5; for if the drain be cut *below the line of the spring*, all possibility of reaching it, even by the auger, is lost, as boring can have no effect where the sub-strata is clay, and where there is no *under* water; and if it be cut *above the line of the spring*, it will require deeper cutting and boring to reach it, as there, for the most part, the ground rises higher, and that part of the porous strata below the drain may contain as much water as injures the ground, and which may easily pass under the bottom of the trench, between the auger holes, and find vent below it. If the expanse of the valley, or bog betwixt two banks, be so narrow that the stratum of rock or sand containing the springs, unites within reach of the auger below the clay, one trench up the middle, with auger holes, will do the business, without any cross or branch drains (see plan, No. 6). Although the springs that injure ground in this

situation break out of the banks all round nearly on the same level, yet the reservoir from whence they proceed may be hit on in the middle of the valley, by boring through the superincumbent body of clay that forces the water to rise and ooze out along the upper edge of it, at its junction with the higher porous ground. The drain being cut in the hollow part of the ground, and the spring below bored into, it is evident that the depth of the drain being so much lower than the natural outlet of the springs, the pressure of water above that level (bottom of drain) will force that under the trench through the auger holes: or even, for some time, until the water subside, it might be made to rise higher than the level of its natural outlet. The consequence of this will be, that the water of the spring having found, by means of the drain and boring, a new and easier channel, will soon abandon its former outlets, and cease to overflow the ground that formerly lay below it.*

But bogs, or wet ground, in similar situations, may proceed from different causes, and consequently require different treatment. The first thing to be considered in examining the ground is, whether the springs proceed from one side only, from both sides, or lie in the middle of the bog. According to these circumstances, the line of drain must be directed. To ascertain this, it will be necessary to use the spirit-level. If the bog have a descent from the side A A to the side B B (see plan, No. 6), although wetness appear all round, it is evident that the water proceeds only from the higher side A A, and passing over and under the surface, part of it is absorbed by the dry ground along the lower side B B; from whence, if the level was not previously ascertained, it might be supposed also to proceed. In this case, one drain cut along the upper side A A, will be sufficient to keep it dry. If the bog have a descent from both sides to the middle, or be perfectly level, the springs may proceed from both sides; and will therefore require a drain on each, if they do not unite in the

* In a valley belonging to Mr. Eccleston, of Scarisbrick, in Lancashire, Mr. Elkington has executed a very remarkable drainage of the above kind. The ground was a mere bog, so soft, that neither horse nor man could walk over it. It contained sixty acres, which, after the drainage, gave 30*l.* of additional yearly rent; and the expense of executing the drains did not much exceed that sum. An account of this drainage has been communicated to the Board of Agriculture, by Mr. Eccleston himself.

same stratum below the middle of the bog, and can be hit on by boring in one drain cut in the centre, as already described.

Where a bog of this nature, between two hills, is of great extent, it may be requisite to have three different drains; one on each side, and one in the middle. This last must be an open drain, to receive all surface water, as well as to cut off any springs that may arise in that part of the bog. In all cases of this kind, where there is any difficulty of discovering from whence the principal springs proceed, or what is the nature and inclination of the sub-strata, the auger may be applied.

In very wet swamps, or bogs of great extent, it is necessary to have other cuts than those that carry off the springs; for although the upper springs, which are the principal cause, be cut off, there may be veins of sand or gravel lower than these, out of which it is also necessary to extract the water. If the ground be to be divided into inclosures, the open ditches may be so directed as to hit on these lower collections of subjacent water, as well as to carry off any that might stagnate in the hollow parts of the surface.

The next thing to be considered is the conducting of the drain, after the levels have been taken, and the true line of it fixed; and whether it should be covered, or open.

If the land be to be inclosed, and as the line of the trench may serve as a proper division of the ground, it may be made an open cut, or sunk fence; if not, a covered drain: but it is first necessary to ascertain which, as the depth, width, and other circumstances, may be regulated accordingly.

After finding the nearest outlet where the water collected in the drain can be discharged, from that a trench must be brought up to the cross one that is to be carried along the line of the spring; allowing a small declivity, of a few inches, in every ten yards, for the water to run.

In cutting the drain that is to carry off the spring, if, after passing the clay, there be a stratum of hard gravel betwixt that and the sand containing the water, it is preferable to lay the *sough* there, being a more solid foundation for it, and either to perforate the gravel with the *punch*, or open small pits through it with the spade; by means of which the water will flow up, and run as speedily off, and with more safety, than if the sough had been laid in the sand itself, which

would not only increase the depth and difficulty of working it, but, in many cases, the level of the orifice will not admit of the drain's being cut to that depth. Also, if in cutting the trench along the *tail* of the rock, the level of the orifice will not admit of its being cut so deep as to touch the rock, the clay, or impervious stratum that lies immediately above it, must be bored through, when the water will flow up through the fissures of the stone, and through the auger holes, into the sough; but it is preferable, in cases where the level will admit, to dig the drain through the clay, and so far into the rock as will furnish stones for laying the sough; and then the water will meet with less resistance, and have a freer issue, than if the stone had not been opened nor broken. This will increase the expence of cutting the drain, but lessen that of quarrying the stones elsewhere, and of carrying them to the place where the drain is made. Although, in the ground to be drained, there may be a ditch, or other old water-course, in which it may be practicable, by means of boring, to *tap* the spring, yet it is better to make a new trench, in which the water of the spring only can have admittance; and where this must cross any ditch, or old water-course, it must be secured by *puddling* with clay, or conveyed in a *wooden trough*, so as not to receive any surface water; which, by being augmented in time of floods, might soon blow up and destroy the sough.

As the water thus obtained by means of boring, may be converted to several useful purposes, as those of irrigation, serving small mills, canals, houses, fish-ponds, pasture-fields, &c., caution is necessary in using the auger, lest the water procured in one part of the drain may be lost at another, in the same manner in which it was found, and in the endeavouring to procure a greater supply: for, as mentioned in Chapter VI, it may, by that means, be *let down from a wet into a dry porous sub-stratum.*

Such are the chief objects that require consideration, before beginning to cut the drains: the following directions will be useful in guiding the execution of them.

If the drain be to be cut through a soft boggy soil, it is better to be open than covered, especially where it may receive other water than that collected from below, and can

at the same time serve as the side of an inclosure, or division betwixt the upland and low grounds. Stones laid in such drains are soon apt to sink, owing to the softness of the bottom, and the sough may also be soon choked up. The width of a covered drain may be from three to four feet at top, and one and a half or two feet wide at bottom, thus allowing six or nine inches for each side stone, and six inches between, for the passage of the water, forming a square conduit,* being also six or nine inches in height. Or, when the quantity of water collected, or to be conveyed in the drain, is small, it may only be coupled at bottom. This is a considerable saving, both in materials and labour, requiring fewer stones, and less time to lay them. It is equally secure when the bottom is solid, the stones good and properly laid, and well packed at the sides, to prevent them from shifting. It is also a saving in cutting the drain, as it requires less width at bottom for this manner of laying the stones, than it does for a square conduit. In most cases, however, where circumstances are favourable, the other method should be preferred. The depth is regulated by the level of the place where the drain is to empty itself, and the nature of the ground through which it is cut, commonly four or five feet, and never less than three.† In soft, boggy soils, it is often

* This part of the drain is called the *sough*, commonly pronounced *surf*.

† When the drain is only to act as a conductor for the water brought up by the borer where the soil is *all clay*, its depth may only be three feet, which will be sufficient to allow a proper depth of earth above the stones laid for the conduit at bottom, which need not exceed, nor should ever be less than, one and a half or two feet. I have seen a drain, in ground apparently very wet on the surface, cut to the depth of three, and even four feet, and several hundred feet in length, without any water being collected by it, and when the borer has been applied, and holes put down at the distance of six yards apart, and eight or ten feet deep, a considerable stream of water has been procured, and which still continues to flow. In one instance lately, I directed a drain to be cut in a very retentive clay soil, which at the depth of four feet found no water. This gave occasion to the workmen to say, and the proprietor to think, that it was laying out his money to serve no good purpose; but they were soon convinced of the contrary. As the drain had a smooth and uniform slope in the bottom, in order to expedite the work, several men were employed to lay the stones, beginning at the lower end, and proceeding upwards, while others were engaged in boring at the upper end, to proceed downwards. When those below began their work, the drain was quite dry, and no appearance of water, either from the sides or bottom; but by the time they had proceeded a few yards, and two or three holes were made above, an unexpected stream of water made its appearance, to their no small astonishment; and

necessary (if the drain be to be covered) to cut to a much greater depth, or to the bottom of the moss, in order to have a secure foundation for the stones, and as a great part of the water is always lodged between the moss and the next stratum. In digging the drain, it is best to cut the whole length to the depth of two or three feet, at which there is no risk of its falling in ; and when the ground near it by that means has become more firm, and the stones have been laid down by the side of it, then cut to the depth required. In this way the stones are at hand, and ready to lay so soon as the proper depth is dug, and the laying should be begun at the upper side, proceeding downwards, smoothing and clearing the bottom of the drain. By this means, the fall of the water will be seen and kept, as there is a danger (when begun at the lower end, and laying upwards, in level ground), of digging too deep in clearing the bottom, and thereby causing a stagnation of water, and sludge in the sough, which ought carefully to be avoided. In opening the drain, the turf should be first pared off thin, and laid to one side for after use, and all the mould thrown out to the other. The most difficult part of the work is laying the sough in running sands, where it is necessary to have the sides of the trench supported with flat boards and props, which are removed forwards as they proceed in working, and which keep the sides from falling in, and the loose sand from falling amongst the stones with which the conduit is laid. If the sough or conduit be laid with brick, a small aperture must be left betwixt each, to admit the water from the sides of the drain, and the thin turfs must be laid above, grass side downwards, to prevent the mould from getting through the openings.

The turfs are laid, grass side downwards, *immediately above the stones,* without any loose stones above the laid ones, as the water is all collected from the bottom of the drain, very little from the sides of it, and none admitted from the top. Unless, in such cases where the stratum containing the water, or that may receive it in time of rains, is cut through to a greater depth than the height of conduit, then small stones

which has since had the effect of laying dry a piece of very wet ground. This shews, without the use of the auger in like cases, many drains may be cut to an expensive depth, without effecting the desired end, or without making any material change on the appearance of the ground.

must be laid above the conduit or cover stone, to the height of such stratum, or as far up as the water appears to ooze out. These small stones admit the water to subside through their interstices to the conduit or *sough* below, and thus prevent the bad effects that would otherwise proceed from its confinement so near the surface.

In quick or running sands, turfs must also be laid in the bottom of the drain, under the sough, to prevent the loose sand from flowing up, and to render the foundation of the brick or stone more secure, in case of their sinking.

Before boring, it is proper to lay the side stones of the conduit; after which the holes may be put down, at the distance of every four or six yards. But if the water, on withdrawing the auger, rush up with violence, and continue to have a boiling appearance, it indicates a strong body of water confined below, and therefore requires a greater number of openings to give it a speedy and sufficient vent. When the force of the water is great, the width of the holes enlarges, and consequently the discharge is increased. By a careful examination of the adjoining ground, it is sometimes possible to say at what depth the stratum containing the spring lies, and consequently how deep the *bores* must be made; but the general rule is, to go down till the water rise immediately on withdrawing the auger. Mr. Elkington has bored thirty feet, before the water flowed plentifully.*

In quick-sands, it is better to dig a little into the sides of the trench, off the line of the sough, where the auger is to be used, and, after boring, to cover the places in the same manner as the rest of the sough, leaving out a side stone opposite the hole, as the sand thrown up by the spring can thus be more easily taken out with the hand till it subside, and give over running, and is likewise off the main current coming down the middle of the drain. This is shewn by Fig. 1, of plan No. 7, in which the dotted lines represent the width of the drain at bottom, &c. and Fig. 2 is a section of it.

That part of the sough above the auger holes should be left uncovered till the sand is all thrown up, and the open-

* I have experienced the same; but from ten to fifteen feet may be the average. Mr. E. bored a hole thirty feet deep, near Tamworth, in Staffordshire, through which water issued, equal to *three hogsheads* in a minute, and drained a great extent of wet ground in the neighbourhood.

ings clear; but, till then, the sand must be taken out, and the sough may afterwards be covered up with safety. Above some of the auger holes, or at any other convenient part of the drain, a kind of funnel may be built to the top of the trench, with a flat stone laid over it, whereby it can at any time be looked at, to see if the issue is clear, and if the quantity of water diminishes or increases. When the circumference of the auger holes is not sufficient to let up the quantity of water which the spring would otherwise issue, where it is not far from the bottom of the trench to the stratum containing the water, and where there is a bed of hard gravel intervening, impenetrable by the auger, holes must be dug with the spade, down to the spring, and these holes filled up with loose stones, first putting down a round stake in the middle, which, after the stones are filled in, must be drawn out, and this leaves an opening for the water to flow up. No apprehension need be entertained of the holes made by the auger being filled up, whether the drain be open or covered, provided no other water is admitted; for, such is often the force of the spring, that it will throw up any earth or other sludge that may accidentally get into it, and can be injured only by the admission of great quantities of surface or flood water coming upon it at once.

When flat stones can be got, they are preferable to brick; but there are several kinds of brick, besides the common sort, invented and used solely for the purpose of draining, in several parts of England, where the expense of stone would become greater. Of these, the figures in the annexed plate are some of the best kinds.

When small drains are wanted, and when the water is to be conveyed to a house, &c., No. 1 is commonly made use of.

For larger drains, No. 2 and 3 are well adapted, especially No. 3,* lately invented by Mr. Couchman, of Bosworth Temple, in Warwickshire, and with which Mr. Elkington has laid several drains.

They are laid single, without one reversed under; for, when that is done, the water running on the under one, occasions a kind of sludge, which in time becomes so encrusted on it, as totally to obstruct the passage of the water, and

* The tax ought certainly to be taken off such bricks as are used in draining only, and which cannot be applied to any other purpose, as those above-mentioned.

render the work useless in a few years. In clay bottoms they may be laid single, or without any thing under; but, in soft sandy bottoms, a common building-brick should be laid under each side, to prevent them from sinking down, and should be so laid as to form a regular arch (*i. e.* the side bricks laid with an equal height), the better to support the pressure above from breaking them, or causing them to slip. They may be constructed in the above shape, to any dimensions suitable to the quantity of water the drain is to convey.

Although the earth that is thrown out of the drain should, when filled in again, be considerably higher than the surface of the ground on each side, it must remain so; for, in a year or two, it will subside to the level of the surface on each side. What remains may be spread or laid in some adjoining hollow; for, if levelled at first, the earth immediately above the drain sinks down, and the rain, by that means lodging in the hollow, and subsiding downwards, may injure the sough, by carrying part of the earth along with it.

While the drain is cutting in very wet peat soils, the surface water, or what may ooze from the sides, before coming to the spring, must be stopped here and there, and when let out to run through the sough, a turf, or bunch of grass, must be laid so as to prevent any sludge which it may bring down from running through along with it, as this might choke the laid part of the drain, and stop the passage of the water. When the trees, especially ash, happen to be in the course of the drain, they must be entirely *grubbed* up, otherwise the roots will get into the sough, and expanding through the joints of the stones, will soon put a stop to the passage of the water.

When the water issued by the drain becomes of a red *ochrey* colour, it indicates a stagnation either from the above cause, if amongst planting, or from some part of the sough having fallen in, which should be speedily repaired, otherwise the ground will soon become equally wet as before.

Lastly, the mouth of the drain should be carefully railed in, or otherwise guarded, to prevent the cattle from trampling it, or choking it up, being fond of drinking there for the sake of the cool water, even although there be watering places in the field; and where there is any defect of this kind, it should immediately be remedied. Likewise the outlet of the drains where they empty into an open ditch, or run of water,

should be often examined and kept clear, as they are very apt to be choked up with grass and sand, when neglected, in such places. The first symptoms of the drain's having effect, and which soon appear when the spring is properly *tapped*, are, that all the *surface drains* that may have formerly been made, and also any adjacent pits, ditches, or places to which it may have *backed up*, immediately become dry, and remain so afterwards.

On the whole, it appears from the foregoing observations, that this mode of draining bogs, or land injured by subterraneous water, is by far the most effectual of any that has yet been suggested; and that such ground may be made completely dry, by *cutting off one spring alone*, with which the particular place to be drained may have no apparent communication, but which may be so connected *under ground*, that from it all the others derive their source; and being therefore the *principal cause* of the whole, *to hit on it*, seems the chief desideratum of the business. Of this there are many instances in Mr. Elkington's practice, where, by a few auger holes hitting on the particular spot where the *lowest part of the main spring lay*, a considerable extent of ground, with which his drain had seemingly little connexion, has been laid dry, to the astonishment of those who have seen it, and furnishing a subject of incredibility to many who have not.

At Odstone Hall, in Leicestershire, a very remarkable instance may be seen. A considerable tract of wet marshy ground, of very little value, divided in the middle by a small river, he so completely drained, by making a small trench at one side, and by boring in it, that the part of the marsh on the opposite side of the rivulet, which was at a very considerable distance from the drain, became in a short time equally dry with that where the cut was made; has continued so ever since; and, from being formerly of little or no value, is now converted into excellent *water-meadow*, producing, *without manure*, abundant crops of grass.

At Madely, near Newcastle, in Staffordshire, there is a very considerable bog, of some hundred acres; the drainage of which was always deemed impracticable, being of so wet and soft a nature, that no cattle could pass over any part of it, till of late Mr. Elkington, having obtained a lease of it for a certain number of years, has, by means of very little cutting

and expense, so effectually drained it, that it may now be considered not only one of the most wonderful undertakings of the kind so easily accomplished, but is also, from the other improvements making on it, likely soon to become one of the most productive farms in that part of the country.

At Woburn, in Bedfordshire, he has lately accomplished the drainage of two extensive bogs, belonging to His Grace the Duke of Bedford, in a manner attended with little expense, although they were formerly reckoned irreclaimable.*

By drains, too, which he has made, pits and wells at a great distance have been laid dry, and distant springs have abandoned their former course.

Many more instances of remarkable drainages of the same kind, executed by Mr. Elkington in different parts of England, might be mentioned; but as they are all founded on the principles I have explained, and executed in the same manner, the preceding may suffice as evidences of their success; being *facts* no less true than astonishing, and which are taken notice of in the Agricultural Reports of the counties to which they belong, as shall be shewn in the sequel.

In corroboration of these facts, since the publication of the former edition of this work, many extensive and successful drainages have been accomplished, under the direction of the author, in different parts of Scotland.

In cases of such similarity, to mention the particulars of each would be tedious and uninteresting; but above others, that in the extensive park of Dalkeith, belonging to the Duke of Buccleuch, is worthy of being mentioned. In all the parts of the operation, it has been carried on in exact conformity to the true principles of the system, and according to the rules and directions given for the drainage of spring bogs (Class 1st.); the plan of which is also applicable to its nature and situation. Besides rendering the ground dry, and much more valuable, these drains have likewise served another useful purpose, that of affording a constant supply of spring-water to different parts of the park.

* One of these bogs was agreed on by a Committee of the Board of Agriculture, as a proper subject for trying Mr. Elkington's skill. Accordingly, he began the drainage in 1795; and when the author saw it in the summer following, the intended drains were not then all cut; but judging from the effect of those that were, there was every appearance of success, when the whole should be completed.

CHAPTER IV.

DRAINAGE OF HILLS AND SHEEP-PASTURES, WITH OBSERVATIONS ON THE MEANS OF PROCURING AND RAISING WATER FOR WELLS, &c.

In hilly countries where sheep are the staple produce, less attention is paid to the drainage of such parts of their walk as are wet and unproductive, than to that of arable ground, although the effects in the one case are equally beneficial with those in the other. This neglect is often attended with considerable loss. From the nature of the herbage, which a superabundance of moisture produces (whether stagnant on the surface, or long confined under it), proceeds that almost incurable malady the rot, to which so many thousands of valuable animals fall a sacrifice. For this, draining is the most infallible preventive; and in such situations it is attended with little expense, as the drains may, for the most part, be left open, with only here and there covered passages, over which the sheep may cross with safety.*

And although in places where the depth of the cut does not reach the spring, the auger must be applied, no apprehension need be entertained of the holes filling up where the drain is left open; for the force of the spring will, of itself, throw up any sand or sludge, that may get into them, provided no great quantity of flood or surface-water is admitted: but, the better to secure them against any obstruction, small openings may be made in the upper side of the trench; and in these the perforations may be made, leaving the mouth of the auger holes about a foot higher than the bottom of the drain, which will be without the reach of the water that may be accumulated in time of rains. See Fig. 3, of Plate No. 13.

From the irregular disposition of the component strata,

* It is the practice in many of the southern sheep-farms of Scotland, to cut small open drains in the wet pastures, only one foot in width, and the same depth; but this has very little effect, either in carrying off the superfluous water, or preventing the rot. One rood of the drain here recommended would answer that purpose more effectually than fifty of the other, and, on that account, would not be more expensive.

the sides of many hills are covered with alternate patches of wet and dry soil. By the appearance of the surface and by the vegetables it produces along the declivity, the internal strata, and manner in which they lie, may often be ascertained with such a degree of precision, as to guide the direction of a drain without investigating *below the surface;* for the difficulty or facility with which such ground may be drained, depends entirely upon the *lye* of the different strata of which the hill is composed, and upon the perpendicular or horizontal inclination of the rock or body in which the water is contained. If the rock lies in a horizontal direction, all the different outlets, or springs that appear on the surface, may proceed from, or be connected with, the same body of water, and may all be *dried up* by cutting off or letting out the main body of water that supplies them, at the lower part of the reservoir, or place where the water would of itself run off more easily, if it was not confined under an imperviable covering of clay. But,

Where the rock lies in a perpendicular manner, and contains only partial collections of water amongst the more open fissures of the stone, which empty themselves at numberless outlets unconnected with one another, it would be preposterous to attempt cutting them off by *one drain*, or by *tapping* any particular one of them, without a drain being cut into each. See Plan marked No. 8, Fig. 1.

In this manner, it is better to cut the main drain *all in the clay*, with small cuts up to each outlet, than along the dotted line, or place where the springs break out; as it would in that direction be *too much in the rock*, and difficult to cut, from the nature and inclination of the stone. Where the water issuing out along the dotted line, can, by means of the auger, be hit on in the main drain, at the points AAA, it will be more effectually cut off; but if that is not practicable, the depth of the small cuts will reduce it to such a level, as prevent its overflowing or injuring the surface below.

In many hills composed of alternate strata of rock, sand, and clay, the surface of the latter is commonly wet and swampy, while that of the former is dry and productive, and therefore requires as many cuts to drain it completely, as there are divisions of wet and dry soil. The highest part of the hill being, for the most part, composed of porous soil,

receives the rain-water which descends through it, till it meet some impervious stratum, as clay, which obstructing its percolation any farther downwards, it then rises to the surface, and forces itself a passage over that impassable stratum.

After it has thus overflowed the *upper clay* surface, it is immediately absorbed by the next porous stratum, and descending into it in like manner as above, it again issues at the lower side of it, and injures the surface of the next clay bed, as it did that of the first.

In this manner, the same spring will affect the other similar strata of which the hill is composed, down the whole declivity, and form at last, in the hollow, a lake or bog, if there is not a proper outlet or descent to carry off the water.

To drain a hill-side of this description, it is necessary to begin by making a trench along the upper side of the *uppermost* rushy soil, which will have the effect of cutting off the highest spring; but, as the rain falling on the next porous soil subsides to the lowest part of it, and forms another spring, and as it may likewise be partly supplied from some other internal source, a second cut is necessary there, to prevent that water from injuring the surface of the next clay-bed. Thus similar cuts will be requisite lower down the descent, so far as the same springs and appearances continue to injure the ground, which may produce a quantity of water sufficient to irrigate the lower ground, or which may be useful in some other respect. See Plan, No. 6.

In some hills, the strata of which they are formed lie so regular, that it is practicable to extract the water from either side on the same level, which would be of very considerable advantage in draining the one side, and procuring water for the other; for there is often found on the one side a wet swamp, and on the other the soil too dry. This is owing to the bed of clay that upholds the water not lying horizontally, but *dipping* more to the one side than to the other, and by the one (the dry) side being *overlapt* by a covering of clay, whereby the water is forced to issue at the open side; but if an outlet is given to it on the *dry side*, by means of a drain, lower than that from which it flows on the wet side, the course of the spring may easily be diverted.

The opposite side being porous and covered with sand,

will act as a reservoir to receive the rain water, which will afterwards flow through the opening made in the clay. This may be of great use in supplying a house with water that is situated on the dry side of the hill, and save the additional expense of conveying it in another manner.* See Plan marked No. 8, Fig. 2.

A spring in a low situation adjacent to higher ground may be raised to supply a house, or for any other useful purpose, although much below that level, by confining it in a pipe or brick chimney.

The reservoir from whence the spring or outlet of water is supplied, being confined, and pent up between two impervious strata, and the upper part of it extending perhaps to a considerable height and distance in the high ground, it is evident that, if a perforation is made through the superincumbent stratum into the *tail*, or lowest part of the porous stratum containing the spring, the water may be raised, by confining it, nearly as high as the level of the head of the reservoir. See Fig. 3.

Of this there are several instances in Mr. Elkington's pratice, particularly near Warwick, where he raised the water procured from draining a low meadow, into a mill lead a considerable height above the level of the drain. The drain is closely built with brick, and puddled above with clay, to prevent the water oozing out through the joints. It then rises through a perpendicular brick chimney to the height of the mill lead, by means of its own pressure in some higher ground.

The advantages of such operations must be very great in many situations, and may often be accomplished with success, where many would think them impracticable.†

* Care must be taken in conducting the drain for conveying water to supply a house, &c., not to cut it, or bore in it so deep as to reach a porous stratum, otherwise the water that may have been found at one place, may, by the same means, be lost at another. Puddling may in some degree secure it, but not in every case. Another thing should be attended to in digging wells for a permanent supply of water: although a plentiful flow of water is found in the sand through which the well is digging, before the bottom of that sand is come at, yet for the greater security of always retaining a sufficient supply, it is proper to dig so far into the clay or retaining stratum, by which there will be less risk of the water being lost in dry seasons.

† For an account of experiments in Mr. Elkington's mode of draining, and in procuring water by boring, &c. successfully made by Sir Joseph Banks, see the enlarged Agricultural Report of Lincolnshire.

Of the practicability of this, however, and that water may often be raised to a very considerable height by means of its pressure in distant ground, the following remarkable occurrence, which happened lately in digging a well in the vicinity of London, is a proof. Earl Spencer, for the preservation of his noble mansion house at Wimbledon against fire, and to be well supplied with water, ordered a well to be dug at a little distance from the house, which was sunk to the amazing depth of near six hundred feet before any spring was found. It was begun on the 31st of May, 1795; and, on the 12th of August, 1796, the man who was employed in the undertaking gave a signal to the person above to draw him up, as he had found the spring, and was immersed in water so deep that his life became endangered. In the space of four hours, the water rose to the height of three hundred and fifty feet, and, during two days following, its increase was more than a foot an hour. The water, proceeding from a rock, is remarkably fine, and from the strata it passes through, is strongly impregnated with mineralic qualities. The sinking of this well alone has cost his Lordship about two thousand pounds, but will recompense him by its utility; as, before it was done, the only supply for the family was either rain falling during the wet weather, or water procured from the adjoining fish-ponds. As there is no extent of higher ground near that where the well is sunk, and as the depth of it is some hundred feet below the bottom of the Thames, the source of the reservoir from whence the spring is supplied must be situated at a very great distance, and must contain a very large body of water, to raise it so suddenly to such a height.

Explanation of Plan, No. 9.

Springs and wetness are sometimes found on the top of banks and hills, where the ground contiguous is much lower on all sides; but they are supplied from higher ground at a distance, by means of the substrata or metals lying in the manner represented by Plan, No. 9.

The continuation of the strata C D, is supposed to keep on the same rise, in the high ground north side of the rivu-

let, to a much higher level than the line A B, by which means the springs at E and F, issuing from the *crop* of the metals, are supplied.

By bringing up a cut from the rivulet into the bank at G, an outlet will be obtained for the water, free from that of the rivulet; and by boring or sinking a pit from H to I, the water flowing through the porous strata from C D, to E F, will be reduced to the level of L M, consequently the source of the springs E F, will be intercepted, and the ground on the top and on both sides of the declivity become dry; and the metals, to that depth, may be wrought free of water.

This could not be effected by boring from the bottom of the rivulet, or any run of water, as shewn by the dotted line, for the pressure of the running water above would prevent that below from rising freely, and small stones or sand would be lodged in the hole. If the strata K, crop out to the surface, and cause wetness, the pit, or bore, H I, may be continued till it reach it; but lying at such a depth, and covered with so much clay on the surface, the water contained in it may do no injury to the ground.

CHAPTER VI.

DRAINAGE OF BOGS AND OTHER WET GROUND, BY PERFORATING THROUGH A RETENTIVE TO A POROUS SUBSTRATUM.

In many parts of the country, considerable tracts of land lie waste and uncultivated, owing to wetness in a particular situation, that might by this means be easily drained, and rendered much more productive. The cause of their wetness proceeds, not from springs lying either under the surface, or from the overflowings of any in the adjoining higher grounds, but from the accumulation of rain-water, stagnating on a retentive body of clay or other impervious substance, through which the water can have no descent; and being also surrounded with higher ground of the same impervious nature, the water of itself can have no natural outlet. Such ground, when it becomes boggy, is commonly called *landlocked bogs*. The situation of these bogs, being

often so much lower than the ground that surrounds them, the cutting of a main drain, or conductor, through the bank (as represented by the dotted line in the Plan), for carrying off the water collected by the smaller drains, would in many cases, be attended with an expense greater than the value of such land when drained. The thickness of the impervious stratum that retains and upholds the water, is often so great, that, although the strata under it be of a porous and open nature, as rock, sand, or gravel, the water can find no passage whereby of itself to descend through the one into the other, and therefore, by its long stagnation above, all the coarse vegetables that have for a series of years been produced on its surface, and even the upper part of the soil itself are formed into a body of peat-earth, equally soft, and less productive, than that of any spring bog, and which is only passable by cattle in very dry seasons, when the wind and sun exhale part of its moisture; but it is even then inaccessible to the plough.

The drainage of these bogs must be effected in a manner different from that of spring bogs, the cause of both not being the same. In the following manner it may be done at least expense. The first drain must be made in the middle or lowest part of the ground, and into this all the others must lead. The number and direction of these must depend on its extent. They must be cut through the peat, or wet spongy upper soil, to the top of the clay or retentive substratum, which must be perforated by the auger, in order to give an *oulet downwards* for the water, which will be absorbed by the porous strata below*. The drains should be cut as narrow as possible, and, after the auger holes have been made, and a conduit formed on the under stones

* Making one large pit or well in the middle or lowest part of the bog, dug through into the porous substrata, with the drains leading into it, would answer equally well, and would save boring along each of the drains. "If a pit is sunk twenty or thirty feet deep, in the middle of a field through the Hertfordshire red, flinty, and impervious clay, into the chalk below, when the usual quantity of chalk is taken out, the pit shaft is filled up with the flints taken out of the cahlk and clay, and the top drainage of this part of the field much shortened for ever afterwards, by making principal drains from the part of the field above the level of the top of the pit terminate therein, and the superabundant moisture will escape through the flints in the pit shaft to the chalk below. And if a drain is carried into a limestone quarry, it is seldom necessary to carry it farther.

"In dells or hollows of considerable extent, covered with an impervious

coupled below, they should be filled with loose stones to within a foot and a half of the surface; and this vacuity may be filled up with part of the earth taken out, having a turf, grass side downwards, next the stones. The water and noxious moisture contained in the peat, or upper soil, will be extracted by the drains, and will subside through the auger holes into the porous strata below. If the ground is afterwards ploughed, care must be taken in forming the ridges, and giving them a proper descent towards the main drain, which will greatly assist the others in discharging any heavy falls of rain water. The observations in the annexed note from the Roxburghshire Report, may be useful in this respect, as well as to the future improvement of the ground.

Before proceeding to drain this land in the manner described, the following observation must be attended to: it should be discovered, in the first place, whether the porous strata immediately under the clay is dry, and will receive the water when let down into it from above; or being already saturated with water itself, may, in place of receiving more, throw up a greater quantity to the surface; and thus, instead of remedying the evil, render it worse. This may sometimes be the case, and the sub-strata may contain water that makes no appearance on the surface *at this place*, owing to the superincumbent body of clay, but which, being connected with some higher spring, may flow up when a vent is given to it by the auger. Thus would a greater quantity of water be brought to the surface, which, having no outlet through the circumjacent bank, would render the ground much more wet, and might even, in some situations, almost form a lake. If the surrounding high ground declines deeper or lower than the bog, although at some distance, by means of a

stratum, and from which there is no natural drainage, such as the valley between Mold, the shire town of Flintshire, and the adjoining high land, a pit about four feet diameter, and fifteen feet deep, more or less, as the case may require, is sunk through the impervious super-stratum into a pervious stratum of gravel, and the rain water, and of some adjoining springs, are carried from the surface thereby: the pit is railed round, to prevent cattle from falling into it. I must here remark, that though in this, as well as in many other instances that may be given, the top water escaped through the pervious sub-stratum, the effect might have been directly contrary. I therefore recommend the impervious super-stratum, in all such cases, to be perforated by bore-rods, and the hole made by them is easily stopped up."—*Agricultural Report of Hertfordshire,* page 66.

spirit-level and the appearance of the surface, the nature of the under strata may, in a certain measure, be discovered; and although it should already contain water, a drain can be there cut to draw off that water, and also what is let down into it from above. See letter K in the section of Plan, No. 10, which will help to elucidate these remarks.

It frequently happens, that springs or *spouts* (as they are commonly called) rise in the middle of a field, at a distance from any ditch or open drain into which the water may be discharged; so that a covered drain brought from the nearest outlet, would pass so far through dry ground, as to render the expense of conducting the water from the spout, greater than the injury done by it. To remedy this, begin by cutting a drain a few yards in length, or by sinking a pit into the porous soil immediately between the *lower side* of the wet and next dry ground; and from that bring an upright drain to the *upper side* of the wet ground, from which take a branch to both sides, along the upper side of the wet, so far as it goes. This upper drain will cut off the water where it rises to the surface; the upright drain will convey it to that cut along the lower side of the wet ground, where the water will subside into the porous subsoil. An easier method may be, where the retentive substratum is not deep, first to cut the drain along the *upper side* of the wet ground, and after coming to the stratum in which the water flows, either to bore through the retentive substratum, or cut the drain to that depth, by which means the water cut off above will be let down into the absorbent stratum below, and thus got rid of more easily than by any other method. But, if the ground is steep, and the stratum into which the water is let down *tails out* any where below, or lower down on the declivity, the water will again flow out, and cause a similar *spout*, or wet place in the field. This, however, will seldom be the case, and may easily be remedied by being perhaps near the extremity or lower side of the field.

The following extract from Dr. Nugent's Travels through Germany in 1766, will shew the mode of draining marshes in that country, nearly on the same principles as explained in this Chapter.

"The draining of marshes is conducted in much the same manner as that of lakes; but here I have seen the

operation performed only on what we call moor or turf grounds.

"These are most easily drained by carrying trenches through those grounds, when the disposition of the country is such, that the water can be conveyed to some neighbouring stream.

"The first thing they do is to carry a ditch to the middle of the moor in a direct line, its depth and breadth adapted to the extent and wetness of the ground; and thus to the supposed quantity which is to be carried off. Every six, eight, or ten perches, as the ground is more or less swampy, cross trenches on both sides are drawn in a direct line, and communicating on both sides with the main trench. But in case of water coming from any neighbouring eminences, they dig a trench round the whole ground as a reservoir; and this likewise communicates with the main trench, &c.

"In case the draining of the water into some natural receptacle be not practicable, at least not under a very great expense, then they have recourse to sinking ponds or reservoirs in some neighbouring bottom, and to these they carry all the trenches.

"These ponds are likewise of use as a fishery; but, if even the sinking such a pond be too chargeable, there still remains an expedient which is of good effect, and chiefly if the moors are not too wet and marshy.

"It is the nature of moors in general, that beneath the turf or moss there is a loam which hinders the moisture from penetrating; and this, indeed, is what makes the marsh, and causes the luxuriant growth of the turf or moss; but this loam or clay is only a stratum, and far from being of an immense depth; under it is generally a sand, or some other stony or loose soil.

"Here reason readily informs us, that a middling morass may be drained by *perforating the clay*, and thus make way for the moisture to penetrate. In order to this, a pit is dug in the deepest part of the moor, till they come below the obstructing clay, and meet with such a spongy stratum as, in all appearance, will be sufficient to imbibe the moisture of the marsh above it. Into this pit the ebbing of the morass is conveyed through a trench, and both the trench and the pit are filled up after the first drain with large broad

stones, setting them edgewise, so as to leave interstices for carrying off the water: then such stones are laid over breadthwise, and these covered with loose earth, like that on the surface. When no such stones are to be had, strong piles are rammed down the sides of the trench, and broad boards laid across: and these are covered with earth to a height fit for culture.

"This is a matter of no great expense, the pit being as near the morass as the water will admit, and the trenches but short; then they have a drain unperceived, which leaves the surface of the trenches for the plough; and in middling marshes, especially in such moors as are only wet and damp, this method, though sometimes slow, never fails taking effect; and many tracts are thereby made serviceable to the farmer or grazier."

Mr. Morice has drained a field of fifty acres in the neighbourhood of Aberdeen, exactly in the manner described by Dr. Nugent, from whose publication he took the hint.

The following Extract from the Roxburghshire Report, explains a similar Practice which had been successfully attempted in that part of the Kingdom.

"In the first place, it will be necessary to premise, that from one to six feet deep, below the surface of the waste lands that might be made arable in this country, is found a large seam of black slaty, or metallic substance, generally from twenty to twenty-five feet in thickness; and below this is found a mass of whinstone rock, both lying in a tolerably regular straight line. The thickness of the Whinstone rock, I presume, is unknown, as I have not heard it was ever bored into. The black slaty, or metallic substance, is generally found so closely cemented, as it were, without chinks or fissures, that it is impenetrable even to water, or any other liquid; while, on the contrary, the Whinstone rock, when come at, abounds with chinks and fissures, and will receive and swallow up any quantity of water poured into its bosom. The surface of the earth, above the slaty, or metallic substance, is found every where of a light, kernelly, and

mossy nature, apparently having, in the course of a series of ages, been produced and formed from the vegetable substances which had attached themselves to it: falling in the autumn seasons, and having no receptacle to receive the rain-water as it falls below its stratum, it preserves it on its surface, and in the winter months becomes swelled and enlarged in a considerable degree. In the spring months, when the sun and wind absorb it, and cause it to exhale, the moss becomes of a tolerable firmness, and produces a coarse kind of unprofitable grass, mixed in many places with short heather, of no use either for the rearing or feeding of sheep or cattle.

"Having in a brief manner given you an account of the several strata of which the waste land of this country is composed, which every person in the habit of improving should be well acquainted with, and have, as it were, constantly in view, I shall now proceed to give an example or two of the method of cultivation I took, and then add a few observations. In the year 1784, after I had sowed up my fallow quarter on old land with wheat, and the autumn proving pretty dry, I, in the latter part of October, ploughed up twenty acres of waste lands of the above description, and as one part of it lay nearly on a level, and the other on the slope of a hill, I divided it into two parts, judging it might be necessary to cause each part to undergo a different course of cultivation. The level part I gathered up in small ridges, and ploughed it pretty deep, making the furrows narrow, keeping two labourers following each plough, as well to remove any obstructions that might arise from stones or roots, as also to turn the upper rim or surface below, when the plough was the fault. This done, I allowed it to lay until Midsummer 1785. But in the spring months, as soon as it would bear my sheep and cattle, I drove them up and down the ground as often as occasion would permit, as well to nip off any sprouts of grass that might appear, as to tread it to a firm consistence, and which was attended with most beneficial effects. At Midsummer, having no other fallow that year, I gathered it up again, but finding, although the ridges were getting high, being only set out eight feet at first, the plough did not get to the slaty substance in the hollow of the ridge, I was obliged to lay out the ridges

sixteen feet:— this cost me a deal of trouble; but I eventually got the plough down to the slaty substance. When my work was done so far, my next thoughts were directed to get the water drawn out of the hollow of the ridges, being at least four feet below any level I could obtain. To remedy this, I got a pair of bore rods, which I put down the slaty substance to the Whinstone rock, at sundry places, and which effectually answered my purpose, keeping the tops of the holes or canals covered with a basket of loose stones, which I allowed to remain, or remove at pleasure, as the weather proved more or less wet.

"In the spring of 1786 I had the pleasure to find my waste land was in a condition to sow, as early almost as any other part of my farm; the winter rains falling through the soil upon the ridges into the bosom of the slaty substance, which was laid bare in many places, in the hollow of the ridges, it was gently drawn off, and glided regularly into my canals. In the spring of 1786 I sowed in drills my first crop of Dutch oats, without any dressing, running the drills over with a light roller, to press the earth, and prevent the drought taking hold of and penetrating to the plants, which was of great use: and in the beginning of September, I had the pleasure of reaping a tolerably good crop, of about five bolls per acre; but the quality, as might be expected, was coarse, the stems growing to a great size, which arose from my not giving the drills a sufficiency of seed.

"In the spring of 1787 I gave it two ploughings, and a slight dressing of dung, marl, &c. compounded together, and sowed my second crop in drills again, consisting of Hastings pease; these I sowed pretty thick, and produced a fine crop indeed. In spring 1788, I sowed Dutch oats again in drills as before, which turned out well, both with respect to quantity and quality, and continued to grow the same crops in succession until 1792, when I left the farm.

"I ploughed, on the contrary, the other part of the waste ground on the slope of a hill, in thin broad furrows, using the same measures and precautions as above described, and which I allowed to remain until the Midsummer of 1785 also, when I set a strong brake to work upon it, hoping to tear its upper surface to pieces, and thereby save me a ploughing; but I found myself mistaken in this, for the

surface not being sufficiently covered with earth, had not experienced an alteration sufficient, to yield to the experiment; I was therefore necessitated to prepare it for burning; but the weather proving wet at the end of the summer, rather foiled me, and obliged me to give up any farther progress for the season, and leave it in a more backward state than the part first mentioned.

"In the spring of 1786, I gave it two ploughings, braking, &c., but it still proving large and lumpy on the surface, for the reasons before assigned, and despairing of its growing any thing, I at last, after much deliberation, determined to sow it in drills with pease, giving it a large quantity of seed, not with a view of a crop so much as covering the surface close with the plants, and thereby accelerate its cultivation. The number of plants pushing forward at the same time, for want of air at the roots, greatly weakened one another, and proving in the end of a dwarf kind, produced me a good crop, at the same time that they improved the lands in the way I expected. In 1787 I sowed Dutch oats, in the way and form before described, changing the seed yearly, until I left the farm, as mentioned before.

"As the soil above the slaty substance was not above two feet and a half deep, the plan of setting off the ridges eight feet broad in this part of the land, answered well.

"Being satisfied, from many experiments and observations, of which the above cases will bear me through, that the waste lands in the kingdom arise from the first solid substance found under the surface being impervious and impenetrable to rain, or any other liquid body, as before explained; and as these solid substances lie pretty near the surface, all attempts to improve waste lands will be fruitless, unless the ridges are laid off in breadth proportionable to the depth of the soil, so as to allow the plough to get to these solid substances in the hollow of the ridges; that done, waste lands soon prove prolific and valuable. Excess of heat and cold have the same effect on vegetation; thus in hot sultry summers, we say vegetation is at a stand, being quite burnt up; and, in cold wet summers, we say vegetation is at a stand, being scalded, and hurt by the wet. The first we can only guard against by sowing early; the other we can overcome by draining, &c., which no farmer should omit."

CHAPTER VI.

DRAINAGE OF SOILS COMPOSED OF ALTERNATE BEDS OF CLAY AND SAND.

In districts where the soil is composed of an intermixed variety, and where clay forms the most predominant part, draining is a work attended with much greater difficulty and expense than in those, where both the surface and internal strata are more regularly disposed. In these kinds of soils, where every reservoir of water is unconnected with another, being separated by intervening beds of clay, the partial collections of water that these reservoirs contain are so much augmented in time of great rains, that, being full to the level of the surface of the surrounding clay, the water, having then a free issue, as over the edges of a dish, so overflows and surcharges the surface of that clay, and renders it so wet and sour that its produce becomes every year more scanty and the nature of the soil itself more barren. As these sand-beds have no communication with each other, it requires as many drains as they are in number, to extract the water from each of them. From the nearest and lowest part of the field to be drained, a trench must be cut up to the highest or most distant sand-bank, in such a direction as, if possible, to hit on some of the intermediate sand-beds, and save the making a longer side cut, otherwise necessary; but where this would give many awkward turnings to the main trench, would necessarily lengthen it, and where, by crossing the beds in places higher than the surface of the surrounding clay, would considerably increase the depth of it, and be difficult to work, especially if rock or running sand; drains in the form of letter Y must branch off to such beds, to draw off the water they contain, and to convey it into the leading one, as represented in Plan 11, Fig. 1.

Although the sand-beds throw out the water they contain on all sides, so as to injure the clay surface immediately round them, a drain on the one side will completely extract the water from the whole, and prevent it from breaking out at either side, provided that where it is cut be the lowest.

It may be observed, that, unless the drain is so cut, it cannot be supposed to have this effect, while the water can

find an outlet on the opposite side of the bank lower than the bottom of the drain. This ought, therefore, to be previously considered; and, by carefully examining the ground, and applying the spirit-level, the proper side for the drain may easily be found. Or, if the water bursting out round the bank has been observed in dry seasons to run at one place, and not at the others, it is a proof that this is the lowest point, and, by cutting the drain in the direction of this level, the water will afterwards be prevented from rising to the height of the upper outlets, or above the level of the bottom of the drain, even in the wettest seasons. In many cases, the whole water that causes the wetness, and supplies the other sand-beds below, may arise from the upper springs, passing over the upper soil, and through the different sand-beds; by being prevented from descending deeper than the retaining bed of clay. In this case, the drainage of the whole field may be accomplished with much less difficulty and expense than in the former. After the main conducting drain from the outlet has been cut, the upper drain from A to B (Plan No. 12) must next be made, which will intercept and cut off the principal springs, and may by this means render the lower drains C D and E F unnecessary, unless merely to extract the partial supply of water which the lower sand-beds may receive in time of rains, and which (if these sand-beds are of small extent) can do little injury to the adjoining surface. From this it appears, that one spring rising in the highest ground may be the sole cause of injuring a considerable tract lying below; from its water overflowing the surface at one place, and subsiding into it at another, according to the tenacity or openness of the soil; and therefore, in such cases, the upper spring, or *feeder*, should be first cut off, and the effect of that known, before any more drains are made in the lower ground. This will be better understood from the section of Plan No. 12.

Besides soils corresponding to this description, there are others nearly of a similar nature, but each bed being of less extent, and lying more regularly together, their drainage can be more easily effected by means of less cutting and consequently less expense. Under the beds of sand and clay that thus lie alternately together, and almost parallel to one another, is found a general body of impervious clay, that

keeps up the water contained in the sand, which continues always full, moistening the adjacent clay, and, in wet seasons, running over it. As this *main under-stratum of clay* is seldom above four or five feet below the surface, a drain must be cut to that depth through the middle of the field, if it has a descent from both sides; or, if the ground declines all to one side, the drain must be cut there, where the water will more easily discharge itself into it; and, unless the field is of considerable extent, and have more hollows in it than one, one drain will answer the purpose effectually: for, by crossing all the different beds that hold the water, it will draw it from each. See Fig. 2, Plan No. 11.

The great difficulty, however, in draining land of this description, and which is impracticable by one drain, is, if the direction of the alternate beds of clay and sand lies *across the declivity* of the grounds; so that one drain in this case can have no other effect than that of carrying off the water after it has passed over the different strata, and would here naturally stagnate in the lowest part of the field, if there was no other outlet for it. Therefore, when the ground lies in this manner, which is often the case, besides the drain in the hollow, others must be cut up from it, in a sloping direction, *across the declivity*, which, by crossing all the different veins* of sand, will extract the water from each. See Fig. 3, Plan No. 11.

Where these alternate strata are of greater extent, and the wetness produced by greater springs, forming swamps at different levels on the sides of hills, the method of draining them has been described in Chapter IV.

The first thing to be observed, in the drainage of such alternate soils, is to discover minutely the inclination of the alternate strata, or how they lie with regard to the situation of the field to be drained, as upon this the direction of the drains entirely depends; and as the external signs that distinguish the different beds, are easily perceptible from the appearance of the surface, and difference of the herbage that each produces, there is little difficulty in attaining this part of the object. In drains of this kind, there is seldom any need for applying the auger, as the necessary depth of the trench reaches far enough down, and as there is no spring

* A very thin or narrow stratum.

for want of connection with higher ground, to force itself up through the auger holes, or, if there is, it cannot, at so great a depth, and below such a body of clay, do any injury to the ground above.

The drain, after being formed like a *sough* at bottom, or set like a triangle, must be filled a considerable way up with small stones, before the mould is thrown in, taking care to have *tough sods* laid immediately above the former. Where stones are scarce, and plenty of brushwood at hand, fagots may be substituted in their place with propriety. The under part of the drain, however, should be laid or *coupled* with stones, as a canal to carry off the water subsiding through the fagots, and which has also the good effect of prolonging their duration; for when the water cannot get clearly off, which must be the case where there is no open conduit of stones, its stagnation amongst the branches must soon cause their decay, and choke up the passage of the drain.* There is one thing more to be attended to in completely accomplishing the drainage of these soils. If the field lie very much on the descent, care must be taken in laying out the *branch drains* in a direction sufficiently horizontal, so as not to make the fall too precipitant, by which the bottom of the trenches would be worn uneven, and thus would obstruct the passage of the water, which might soon blow them up; but the fall should be such as to enable the water to clear its course. The reason why fewer drains are required in fields that lie nearly horizontal (as those of the 2d class in this Chapter), is, that the water is drawn equally from both sides; whereas those on a sloping declivity, drawing only from the higher side of the drains, require them to be more in number, or closer to one another. This is the case in every situation where surface draining is necessary, and particularly so in such soils as those described in Chapter VII.

In Lancashire, where these soils composed of alternate beds of clay and sand very much predominate, and which have there acquired the names of *sand pots* or *guts* (a term properly enough applied to them from their holding water like a pot), Mr. Elkington has executed several drainages in the manner I have described; and also a very difficult

* In no case whatever should the drain be filled with stones thrown in promiscuously, without first forming a course for the water at bottom.

one of the same kind at Sutton-hall in Derbyshire, where the water was contained in small beds of rock, crossed and intercepted by beds of clay; and to this Fig. 1, in the annexed Plan No. 11, more particularly alludes.

CHAPTER VII.

DRAINAGE OF SOILS POROUS ABOVE, AND RETENTIVE BELOW, &c.

In flat tracts of land, where the surface or upper soil is injured by a superfluity of stagnant water not proceeding from springs, their drainage is an object of the first importance, and which may, in most cases, be accomplished with very little expense.

The upper soil being composed of a porous stratum, of two, three, or four feet in thickness, and having under this a strong retentive body of clay, the rain-water falling on the surface, easily subsides till it meet the clay, and there being obstructed from farther descent, the whole open part of the soil stands so full of water, as to retard the progress of vegetation, or at least to injure it.* To carry off this water, requires only one or few more drains, according to the situation of the field, and those no deeper than just to reach a few inches into the clay; betwixt which and the under part of the porous soil, the greatest quantity of water will remain stagnant, when it does not appear so much on the surface. In this kind of drainage there is no need for the auger, there being no *real spring*, or subterraneous water, to get rid of.

If it has a small descent from both sides, one drain cut through the porous to the clay soil, in the hollow part of the field, will effectually draw off all the water that the porous soil may contain; which will be greatly facilitated by properly forming the ridges to answer the declivity of the ground, and by deepening and clearing out the furrows with the spade. See Plan No. 13, Fig. 1.

If the situation of the field correspond with the representation of it in the plan, the water will flow into the drain (being in the hollow part of it), through the porous strata, as well as through a number of small trenches cut up from

* This kind of soil is commonly denominated *wet-bottomed land.*

it to both sides, which is the common practice in Essex,* and some other counties adjoining; but it is cutting up a whole field to no useful purpose.

The drain may either be open, if it can serve as a division of the field at the same time, or covered, as circumstances may require.

If a field of this soil has more than one hollow in it, in that case it is necessary to have more than one drain; but if it is almost level, or inclines only a little to one side, a ditch or drain at the lowest extremity, having the ridges and furrows formed, as already mentioned, will answer the purpose effectually. See Figs. 2 and 3 of Plan, No. 13.

In some cases, however, it may be necessary to have a few side-cuts from the main drain, where the field is large or very flat, cut down also a little into the clay, as narrow as it is possible to dig them, and filled with stones, in the usual manner.

Such is the method of draining these soils with most advantage; but many fields suffer equally from wetness, that consist of soil exactly opposite to the former, viz. a *clay surface* having a *porous substratum*.

The drainage of such ground, where the wetness is still of a more injurious nature, and where the impervious stratum that upholds the water is of such a thickness as to require being perforated by the auger, is fully described in Chapter V.; but here, the depth of the drain being sufficient to reach the porous subsoil, without the help of boring, the description of such may with more propriety form a part of this Chapter. Fields of this kind commonly lie very flat, without any declivity, whereby the noxious water, stagnant on the clay surface, might naturally discharge itself without the help of drains; for soils of the same nature, in a hanging situation, are seldom or never affected by the same cause.

Such ground is more difficult to drain, and requires a greater number of cuts than any other soil whatever, as they must be so laid out and conducted as to collect all the water from the surface, which can only discharge itself into the drains *from above*, being unable to flow into them through the clay, as in those soils of an opposite description; and

* From its being so much practised there, this mode of draining is commonly called *the Essex mode of hollowdraining*.

where there is any irregularity on the ground, the water will remain standing in the hollows, within a few feet of the drain. The first thing is, to make one main conductor in the lowest part, or at one end of the field, to receive and carry off the water collected by the smaller collateral cuts, which it may be requisite to make on each side of it. If it suit the situation or division of the field, this main drain had better be open than covered; and then the outlets of the other drains that fall into it can easily be inspected, and frequently cleared out, as occasion may require. The proper formation of the ridges, to answer the declivity of the ground, should be particularly attended to in such soils. The ridges should have rise enough in the middle, to give the water a fall into the furrows; and these should have depth and fall enough to convey it into the drains. Thus would a great part of the rain-water, as it falls, be carried off, which would lessen the number of small cuts, otherwise necessary. The drains should all be dug as narrow as possible, and filled up in the usual manner with loose stones; only the bottom of the conducting drain (if it is not an open one) should be formed in the manner already described, with a small open conduit at bottom, the more easily to carry off the water.

The small drains should also be *coupled* at bottom; *i.e.* two of the largest stones laid in the bottom, inclining on one another above, forming a triangular opening of four or six inches below. As the water is all received in at the top of these drains, it is necessary that they should be filled with small stones so near to the surface as to leave only a space to be filled with *loose gravel*, sufficiently deep to prevent the plough or harrow from deranging them. Loose gravel, if it is at hand, is better than the stiff clay that came out of the drain, as it more easily admits the water to subside through it to the stones; and the other can be spread on any adjacent hollow in the field.

A thin *layer* of straw or rushes* should be laid immediately above the stones, to prevent the smaller part of the gravel from filling up too closely the interstices betwixt them; but this is not so requisite when gravel is used in place of the *mould*. This mode of draining is calculated for

* If the field is in pasture, the *upper turfs, pared thinly off*, will answer this purpose better than straw or rushes.

every tenacious clay soil, whether porous below or not; but, in many instances, the deepening of the furrows, with very few drains, might remedy the evil, where the *retentive upper soil* is only a foot or two deep, with a *porous subsoil* under it, through which the water would easily subside downwards, and again empty itself at some lower extremity of the field. The drains and furrows should therefore be deepened through the clay to the open soil, in order to facilitate the descent of the water; and thus, much depends on the proper ploughing of such ground; by attention to which, many drains, otherwise necessary, might be saved.

The drainage of these soils does not come immediately under the system of Mr. Elkington's practice; but the mode of treating them I have described, he recommends as the most effectual.

CHAPTER VIII.

DRAINAGE OF GROUND LYING ALONG THE SIDE OF RIVERS, AND OF FLAT SWAMPY GROUND LYING BELOW THE LEVEL OF ARTIFICIAL LEADS OF WATER.

Many extensive tracts of land are wet and rushy, from a cause that can hardly be removed by any number of open or covered drains.

This is commonly called *haugh*, or *halm*, land,* and lies along the sides of brooks or rivers, which, having altered their course so often between the opposite banks, and depositing sand and gravel as they recede from their last channel, the water of the *river* always percolates through the ground thus formed to the level of *its* present course, keeping it so moist and wet, as to produce rushes, and other coarse aquatics; and wherever a drain or pit is dug in such ground, it immediately fills with water, to the level of that in the river. Where the river has a quick descent, it is less apt to

* The first of these words is the term most frequently made use of in Scotland, to denote land that has been formed by a river changing its course, and thereby leaving an extent of flat level ground on either, or on both sides of it. This land is always of a very rich soil, being composed of very fine earth, deposited by the water after floods, and washed down from the higher grounds in time of rains. Its drainage and embankment therefore, when necessary and practicable, must always be an object worthy attention.

produce this effect; but where its current is slow, and the level of its surface little below that of the ground on either side, the soil will be very much saturated with water. Any number of drains cut in any direction, can have no good effect, while the river* continues in its present course at such a height. The only remedy, therefore, where it can be done at a moderate expense, is deepening and widening the bed of the river; the earth taken out of which will at the same time serve to form an embankment on either side: for while it can rise higher than the outlet of the drains, and flow back into them, it renders the ground equally wet as before they were made; and the expense of making them is laid out to no advantage. Besides being thus injured by the *river* water, springs, in many situations, issue from the bottom of the higher ground, and ooze through the soil higher than *its* level. The water of these can easily be cut off, and lowered to the level of the river, by a proper drain, as shall be described.

In some cases, the wetness proceeds entirely from springs, where the soil of the flat ground betwixt them and the river does not consist of loose gravel or sand, but of a loam or clay mixture. In this case, the water of the springs is resisted, and prevented from finding its way, *below the soil*, to the river, and therefore is forced to flow nearer the surface, keeping it constantly in a wet *poachy* state, in all seasons. To drain this ground, a trench must be begun at the lower end of it, and brought from the river, along the bottom of the bank from whence the springs issue.

This trench should be cut *below the line of the springs*, where it can be more easily done, and kept open to receive the river water in floods, and also any runs of water from the higher grounds, in time of rains, which would *blow it up*, if covered; and must discharge itself into the river at the lowest possible level.† From this trench, short covered drains must be cut up a little way into the bank, to lead in the springs that are above it (if boring opposite to them has

* This may often be the case, where the run of water does not deserve the denomination of river, and can therefore be more easily remedied.

† If the ground by the side of the river is of such extent as to render a regular embankment along the side of it an object of consideration, a flood-gate might be placed at the mouth of the out-let drain, which would shut with the pressure

not that effect), as represented by Fig. 1 of Plan 8. The bottom of these must be higher than that of the open cut, to prevent any of the water in it flowing back into them. In these also the auger must be used *to tap the springs*, if the depth of this level does not reach the stratum containing the water.

There will be no occasion for any cross drains betwixt the open cut and the river, as all the water that is intercepted will be carried along the bottom of the bank, and emptied into the river at a lower level, unless the ground is of such extent that it may be divided, by cross-ditches, into separate inclosures. The open drain will serve as a division betwixt the meadow and higher ground.

This ground is peculiarly situated, and its soil well adapted for watering, after being drained.

The drainage of many a valuable tract of land is often deemed impracticable, where a mill lead, or other artificial run of water, passes through it, or along the side to which the fall inclines.

From the low situation of the ground, and the height of the water in the lead, there is no fall for discharging into the lead the water of any drains that might be cut to the necessary depth.

To remedy this, there is but one expedient.*

The first thing, is to begin at the river, or natural stream, and bring up a cut to the lead, at the point where the outlet of the upper drains is to cross it. This cut must be as deep as the river will permit, or the drains above require. A cut must then be made across the lead, to the same depth, and a strong wooden *trough*† (of sufficient size to admit the water collected above to pass through it) placed across the lead. The length of this trough must be several feet, on both sides, more than the width of the lead, as marked in Plan No. 14,

of the river-water in a flood, and thereby exclude it entirely from the inner ground, and would open by that of the water accumulated in the drain during the inundation, and so be emptied into the river when it subsides. The construction of this gate is simple, and is the only remedy in cases where it is desirable to have the flood-water excluded.

* In the course of the author's practice, he has had recourse to this expedient in different instances, which has answered the end completely, where no other method was practicable.

† Or square wooden box. Larch wood is recommended for this purpose.

from A to B, and must be secured by stakes driven into the ground on each side, with cross bars above, as represented by Fig. 4, in the Plate. The space between the top of it and the bottom of the lead, must be filled with clay, well beat down. This done, the cut from A to E may be made as deep as the level of the trough will admit, and so continued along the upper side of the wet ground, to cut off the springs that rise in that quarter. This may either be a covered drain, or open, as circumstances may require. From the trough, also an open cut should be made parallel to, and along the back of the lead, to receive the surface water from the ground above, and from the division ditches that may be necessary, if the ground is of great extent. The earth from this cut should be laid between it and the lead, to strengthen and secure the bank. In like manner, an open cut may be necessary along the other side of the lead, to receive the water that may ooze from it, and injure the ground between that and the river; and this ground, if extensive, may likewise be divided by cross ditches,* as represented by the dotted lines.† The cross or division ditches in the upper part of the ground, must not join the upper drain, but a small space must be left uncut at the letter D, to prevent any connexion between the spring-water in the upper drain (especially if covered) and what is collected in the cross open ditches; and will likewise serve as a passage from one division of the field to another.

CHAPTER IX.

DRAINAGE OF MINES, QUARRIES, MARL PITS, &c.

THE principles of Mr. Elkington's system have hitherto been confined only to the draining of land, or taking away *subjacent water* that injures its surface; but there is no doubt that it might be equally successful, and of very material im-

* Where the word ditch is used in place of drain or cut, &c. it implies, that it may likewise serve the purpose of a fence, or side of an inclosure, as well as a drain. For the sake of ornament and shelter, hedge-rows should be planted upon the banks of the ditches.

† This part of the ground is well adapted for irrigation, where the command of water may be sufficient for supplying the lead, and likewise affording a sufficient quantity for this purpose.

portance in the case of mines and quarries ; by diminishing the quantity of water that is frequently found in the course of working them, and which very much obstructs, and even sometimes puts a stop to the work altogether ; at least it very often does so, in quarries of freestone, limestone marl, &c.

Thus, from the want of Mr. Elkington's method being known, many mines and quarries at present lie unwrought, from the fear of water and quicksands, which might otherwise be wrought to advantage.

It is well known that all springs and subterraneous collections of water are supplied from ground lying higher than that where they are found ; which being of a porous nature, admits the rain to filtrate through it, which descends often to a very great depth through the pores of the open soil, rock, sand, gravel, &c. before it be obstructed by some impenetrable stratum. Thus, in sinking a pit for coal, or any other subterraneous mineral near the bottom of a hill or high ground, a bed of quicksand is met with, so full of water, that to pass through it becomes a very difficult and expensive operation ; and as this water proceeds from the porous ground lying above it, it may in many cases be practicable, to intercept the greater part of that water before it reach the sand-bed in the pit, and by means of *tapping at the tail of the sand-bank* (provided the ground naturally declines lower than where the sand is found in the pit), the whole of the water may be extracted from it, at a comparatively small expense with what is used as the common remedy in like cases.

To accomplish this, in ascending, from the pit, carefully examine, if higher on the declivity, any bed of rock, sand or gravel, *tails out*, which may convey the water contained in it to the sand-bed below ; and if such bed is found, a drain may be cut into it, which will carry off a great part of the water, and consequently lessen the quantity of water in the mine, which would otherwise have continued to descend through the porous substrata, before being thus intercepted in its descent. But although this is done, and the supply from above entirely cut off, yet a sufficient quantity of water to injure the pit, may continue to ooze from the sides of the sand-bed, even supposing it should *dip* towards the lower ground, which if it does, that water may be easily drawn off at some point in the low ground.

To effect this, in order to remove the above inconvenience, in descending from the pit, along the declivity, endeavour to discover at what place in the low ground the sand terminates or *tails out*, which may be found by means of a spirit-level; and if there is any appearance there of the water's having a natural outlet, it may, by means of a deep drain, be much quicker and more effectually drawn off; for springs naturally flow through narrow and crooked perforations, and consequently, whenever the orifice is enlarged or made lower, the discharge of water becomes greater. But, if there is a deep covering of clay above the tail of the sand, in that case a drain can only be cut so far into it, and by means of boring through the remaining portion of clay, an easy outlet may be given to the whole water contained in the above sand-bed.

This will also, in a great measure, remove, or at least relieve, the difficulty that would afterwards have attended sinking the pit; for the water thus cut off must lessen the quantity that would have been found deeper, the same body perhaps passing downwards from stratum to stratum, so far as they continue porous, or capable of receiving it.

It is, therefore, of material consequence to drain all ground lying higher and contiguous to mines, or any other deep subterraneous pits, for the reasons already given; and on these principles, and by these means, it may be accomplished with little difficulty or expense.

The water found in the bottom of the pit or mine must be got rid of in a different manner, as the ground may perhaps nowhere decline lower than the mouth of the pit. For it is only on the supposition of the different strata and sand-bed *dipping* with the natural inclination of the surface, that the above method of proceeding is practicable, or on the supposition of their lying nearly horizontal; but, should they lie in a reverse direction, there is little possibility of accomplishing the object, unless their termination can be hit on, somewhere on the opposite side of the hill, which, by ascertaining the precise inclination of the metals, and by exact levelling, may very nearly be found out. In most cases, however, the upper strata above coal are found lying pretty regular.

But, as a description alone, without an explanatory sketch, cannot so clearly convey an idea of the nature of it, Fig. 1 of the annexed Plan, No. 15, will help to elucidate these remarks.

UNIVERSITY OF ILLINOIS LIBRARY AT URBANA-CHAMPAIGN

The foregoing observations so far explain how the water may be cut off that is met with in sinking the shaft, before reaching the coal or other mineral that is sought for; the water that is found in the bottom of the pit, or what proceeds from the rocks, &c. in the course of working the mine, is commonly got rid of by means of an engine-pump; to assist in working which, the water obtained by means of the drains already described, may be very useful, where the stream for that purpose is deficient, in saving the great expense of working it by steam.* But, without the help of a natural stream, which may be converted to the above purpose, it is seldom possible to find, by means of drains or otherwise, a quantity of water sufficient to drive such weighty machinery, in a situation high enough to have the necessary command of it. It may, however, in many cases, be a valuable acquisition. See Plan 15, Fig. 2.

In situations where a proper command of water can be obtained, and where the entrance to the mine is likewise adapted for the purpose, the use to which it may be converted is still more advantageous, by driving machinery to bring out the minerals, and also for working an engine

* That letting down the water by boring into an inferior open stratum, even in the bottom of the pit, may not only be practicable in some cases, but of very great advantage, the following observations will shew.—"The water was raised by a steam-engine about sixty yards, from a colliery in Yorkshire, which had been wrought several years; the proprietors bored down to the depth of about ten yards farther, to ascertain the depth and thickness of a seam of coals, which was supposed to lie below those then wrought; the workmen employed bored from the bottom of the pit next the engine pit, and when they had bored to the above depth, and taken out the rods, the water from the works, which usually ran across the bottom of this pit to the engine-pump, ran down the hole they had then made. As soon afterwards as the steam engine was set to work at the stated period (about one hour in twelve), the engine-pump contained little or no water; it had escaped through this hole, and continued to run through the same ever afterwards, and rendered the engine useless. This instance of water at so great a depth from the surface, finding a passage at a further depth of ten yards, or less, and immediately below, is very singular and striking. The situation was much higher than the next adjoining valleys and the level of the sea. Experiments of this sort seldom fall to the lot of man to make, therefore such instances are rare and uncommon. But in large tracts of level land, where lakes or morasses have been formed, and which cannot be drained by cutting open drains, or driving levels through rocks, but at an expense for which the lands, when drained, would never compensate, the above instances warrant experiments being tried with boring rods, which, if not successful, may be tried at little expense."—*Agricultural Report of Hertfordshire*, page 67.

pump, for clearing the mine of subterraneous water, flowing from the cavities of the rocks that are met with in working. His Grace the Duke of Buccleuch's coal-works, near Langholm, in Dumfriesshire, are a striking example of this, and of the superior powers of water and machinery when properly combined, where a command of the former can be obtained, and when the latter is constructed on proper principles, and conducted with that care and ingenuity which are necessary in such undertakings.

It frequently occurs, in working quarries of lime or freestone, that, at a certain depth, part of the rock containing water is hit on, whereby the quarry is soon so filled with water, as to put a stop to working it deeper, where the best of the stone lies. The common remedy in such cases is, either to erect a windmill pump, to draw out part of the water (for the whole cannot be taken away by this means), or to open a new quarry adjoining to the last, which at the same depth meets with the like obstruction, or to bring up a very deep and often expensive cut, under the level of the water, from the nearest declivity.

By the following method, however, all quarries of limestone, freestone, marl, &c. liable to such an obstruction, may be completely cleared of water at little expense; and the drain, at the same time, will serve a double purpose, by drying the wet ground, which, in consequence of the spring contained in the rock, is found adjoining to it.

Immediately under the rock commonly lies a bed of strong retentive clay, that upholds all the water received by and retained in that rock, and which being also bound round on each side by a covering of clay, or other stiff soil, cannot discharge itself, and therefore stands always so full in the rock, as to prevent taking out the stone to the bottom.

In the first place, endeavour to find to what side the rock *dips* or inclines, which may easily be found by the appearance of the surface in examining the adjacent ground, and by the assistance of a spirit-level. After discovering this, cut a drain through the clay covering to the rock, by which the water will be drawn off, that for want of a proper outlet formerly stood pent up in the cavities of the stone. See Plan No. 16, Fig. 1 and 2.

Sometimes the evil may be remedied in a different manner.

It often happens that a bed of the same stone, of a close compact nature, is found lying under one of a more open kind, with pores and fissures in it admissible of water, which so keeps up the water in the upper bed, that none of it can pass through to an inferior open stratum; and on sinking through this stone, another bed is found, of so open and porous a nature, as to admit the reception of any water from above that may come into contact with it.

Sometimes a bed of gravel or sand is found under the close stone, which being still more capable of absorbing any water let down to it, is better calculated for the purpose of clearing the upper bed of stone from water, than a stratum of open stone itself.

When this is discovered to be the case, and the water *kept up* by the second bed of stone, so as to be prejudicial to the working of the upper bed, and which will be equally so in working the second; the work may be greatly relieved by boring through the close bed of stone, and letting down the water into the more porous one below, or into a stratum of dry sand or gravel, if there be such under it. In place of boring, sinking small pits through the close stone is a more effectual method of letting down the water, but a more difficult one to execute.

At Ormskirk, in Lancashire, stone quarries are cleared of water exactly in the manner above described, which Fig. 3, in the annexed Plan, will better explain.*

* To shew the success of this practice, Mr. Eccleston, of Scarrisbrick, a very ingenious member of the board, and proprietor in the neighbourhood of Ormskirk, communicated the following information:—"In stone quarries, wells (pits) occasionally are sunken to the open bed, which have proved serviceable. The above was practised in a stone delf near Ormskirk with success. But in order to lay the delf more effectually dry to a greater depth, Mr. Elkington having viewed the country, marked where he thought the rock terminated or tailed out, and at the lowest level set out a drain to be cut up to the rock, part of which work is executed, and a very considerable spring comes from it; but, on account of the great depth (sixteen feet), it will not be finished before he has seen the work again. The drain he has laid out is about ten feet lower than the bottom of the stone quarry, and when completed, will lay that head of stone dry lower than the present floor. All rocks mostly where they terminate are succeeded by broken loose stones of the same nature as the rock, and they are frequently (not to say always) succeeded by sand, which, when a thick bed, and of a running nature (quicksands), often cause great expense to cut through to the tail end of any rock." See Plan 11, Fig. 2.

In such cases as this, where there is danger of meeting a quicksand, boring or sinking pits through the bed of close stone is the most advisable and least expensive method.

The situation of marl pits is commonly such that it requires a very extensive cut through some part of the surrounding bank, to carry off the water that prevents taking out the marl. This might often be accomplished in a much less expensive manner, by sinking a pit through the retaining stratum under the marl bed, into some absorbent stratum below, that would receive the water let down into it by the pit. If the ground where the marl lies is of considerable extent, several pits will be necessary to carry off the water. If they require to be so deep as to be in danger of falling in, they should be built round the sides, or filled up to near the top with loose stones through which the water can subside. Any cross drains or cuts necessary for collecting the water, must be conducted into the pits. In many cases the water may be got rid of in a still easier manner, provided the situation of the ground is answerable. If the surrounding bank declines on the opposite side *lower than the water*, by cutting a drain into it, and boring with a *horizontal auger*, into the *tail* of the stratum containing the water, it will be drawn off and reduced to a level lower than that of the bed of marl. As this water is often supplied by a spring, rising in some part of the higher ground, and descending into the place where the marl lies, in such case it will be necessary to cut off the source of this spring, and divert it into some other channel. By doing this, the quantity of water below will be lessened, and more easily carried off by means of the pits or drains.

CHAPTER X.

OBSERVATIONS ON THE USE OF THE SPIRIT-LEVEL, AND DIRECTIONS FOR USING IT IN MARKING OUT OF DRAINS, &c.

After the *main spring*, or that from which the others derive their source, has been discovered, the ascertaining a line on the same level, to one or both sides of it, for the better and more sure direction of the drain, being one of the first and most important parts of the operation, and the one on which Mr. Elkington's art in a great measure depends (for before him, it is believed that no man ever thought of ascertaining, by means of levelling, the course of water in the bowels of

the earth), a description of it may prove useful to those who have never been in the practice of using the spirit-level for that purpose.

Being provided with a spirit-level (which it is necessary to have previously adjusted), and a staff about ten feet in length, with a movable vane or sight affixed to it, set up the instrument in a situation between the object from whence the level is to be taken and that to which it is to be directed, provided the distance from the instrument to each of them be not too great. The situation of it should also be no higher than the length of the staff will answer, and so as it may be seen from it both ways; then direct the man with the staff to hold it at the *main spring*, or place from whence you mean to carry the drain; and, after directing the telescope to the staff, and adjusting it to a level, make a sign to him to move the sight up or down, till it be exactly opposite the cross hair in the telescope. This done, without shifting the instrument from its first position, and cautioning the man to fix the sight to the staff at the point directed, he may proceed forty or fifty yards farther; and after having again adjusted the level, make a sign to him to move to *higher or lower ground*, till the sight on the staff coincide exactly with the cross hair in the telescope. He may then leave a peg at the place where he held the staff, and proceed in like manner to other stations, till the whole line is finished, leaving pegs, or making pits, at the places where the staff was held.

If the length of the line to be levelled requires the instrument to be shifted from its first position, the level must again be taken from the last station where the staff was held, and the sight on it fixed in the proper place, as before directed, proceeding in the same manner at every forty or fifty yards in length, till the whole is accomplished. After the line is thus levelled, and ascertained by marks left at every station where the staff was fixed, it may again be examined, and other pegs put in between the first, the better to direct the workmen in cutting the drain, giving the line such turnings, and even small deviations from the course of the level, as may shorten or straighten it, and humour the situation of the ground.

For the sake of accuracy, where the work requires it,

especially if the water is to be conveyed any considerable distance, or wanted to supply a house, or for the purpose of irrigation, the levels may be proved by reversing the former line of direction. The spirit-level is also necessary for ascertaining how much fall can be obtained from the drain to the nearest outlet where the water can be discharged, the shorter that distance being the better, provided fall enough can be got.

It is often necessary to level a much longer distance than the length of the drain may require to be cut; but when the level of the whole line is known, and the nature of the ground carefully examined, short drains can be cut on that line, with openings (places not dug out) between, which will answer the purpose equally as well as one the whole length; and the expense will be considerably less, provided the length of the conductors for the water from each be less than that of the openings or places not cut: but if the whole line, with only one conductor, be shorter than these, it is better to have all the water discharged at one orifice. The level has frequently to be taken from a spring or well, at a considerable distance from the ground to be drained.

The American level, as it is sometimes called, being first communicated to the President of the Board of Agriculture by Dr. Edwards, of America, is so simple and useful an implement for ascertaining the level of drains or water-courses, that I have thought proper to subjoin a description of the method of using it, and have given a drawing of it in Plate 17, No. 5.

It is formed of two pieces of thin wood of equal length, joined together at top, and connected below by a cross bar. From the angle at top, a lead or plummet is suspended by a small cord, which, when the instrument stands level on both legs, strikes upon a mark in the centre of the connecting bar, as represented by Fig. 5, in the Plate. The manner of using it is simply thus:—At the place from whence the level is to be taken, drive a wooden peg into the ground, close in to the top, upon which one of the legs of the frame may rest; then bringing round the other leg till it touch the ground, there drive in a second peg, and the space betwixt them will be level. In proceeding forward, rest the leg of the frame upon the top of the second peg, turning

round the other leg as before; and where it touches the ground again drive in another peg, and so on along the whole line to be levelled. Thus, with very little trouble, and with as much accuracy as with the finest spirit-level, will the course of the drain be easily ascertained. But, as it is necessary that the drain should have as much declivity as to allow the water to run freely, it will be requisite in taking the level to regulate the direction of the line accordingly. Half an inch in the length of the frame will be sufficient. For this purpose it will be expedient to have, besides a number of wooden pegs, one iron pin, with inches and halves marked regularly upon the sides of it, from the top downwards. After having driven in the first wooden peg at the point from whence you mean to conduct the drain, and having rested the one leg of the frame upon it, turn round the other till it be level with the first peg. There put in the iron pin, so that this leg of the frame may rest on the top of it when level; then drive in a wooden peg so far as that the top of it may be one half-inch lower than that of the iron pin. Place the leg of the frame again upon this second peg, turn it round to a level, putting in the iron pin till the top of it be equal with the foot of the frame; then drive in another wooden peg close by the side of it, till the top of the wooden one be half an inch lower than that of the iron pin. Proceed in this manner so far as you mean to carry the drain, which will have the same degree of declivity all the way along. A line thus set off, is marked from A to D in the Plate. When made on a smaller scale, it is useful in ascertaining the proper descent along the bottom of the drain, while the workmen are laying it; but when made for this purpose, the cross bar must be fixed to the bottom of the legs, as marked with dotted lines in the Plate.

CHAPTER XI.

DESCRIPTION OF THE AUGER, AND MANNER OF USING IT, &c.

The borer used in draining, is nearly similar to that made use of in searching for coal or other subterraneous minerals. The auger, shell, or wimble, as it is variously called, for

excavating the earth or strata through which it passes, is from two and a half to three and a half inches in diameter; the hollow part of it one foot four inches in length, and constructed nearly in the shape of the wimble used by carpenters; only, the sides of the shell come closer to one another. The rods are made in separate pieces, of four feet long each, that screw into one another, to any assignable length, one after another, as the depth of the hole requires. The size above the auger is about an inch square, unless at the joints, where, for the sake of strength, they are a quarter of an inch more. There is also a chisel and punch for screwing on, in going through hard gravel, or metallic substances, to accelerate the passage of the auger, which could not otherwise perforate such hard bodies. The punch is often used when the auger is not applied, to prick or open the sand or gravel, and give a more easy issue to the water. The chisel is an inch and a half or two inches broad at the point, and made very sharp, for cutting stone; and the punch an inch square, like the other part of the rods, with the point sharpened also. There is a shifting handle of wood, that is fastened with two iron wedges affixed to it, for the purpose of turning round the rods in boring, and also two iron keys for screwing and unscrewing the rods, and for assisting the handle when the soil is very stiff, and more than two men required to turn it.

To judge when to make use of the borer is a difficult part of the business. Some who have not seen it made use of in draining, have been led into a mistaken notion, both as to the manner of using it, and purpose for which it is applied. They think, that if by boring indiscriminately through the ground to be drained, water is found near enough the surface to be reached by the depth of the drain, the proper direction for it is along these holes where the water has been found, and thus make it the first implement that is used. The contrary is the case, and the auger is never used till after the drain is cut, and then for the purpose of perforating any retentive or impervious stratum lying between the bottom of the drain and the reservoir containing the spring. Thus does it greatly lessen the trouble and expense that would otherwise be requisite in cutting the trench to that depth, to which, in many instances, the level of the outlet will not admit. The manner of using it is simply thus: — In working it two, or

rather three, men are necessary. Two stand above on each side of the drain, who turn it round by means of the wooden handle; and when the auger is full, they draw it out, and the man in the bottom of the trench clears out the earth, assists in pulling it out, and directing it into the hole, and who can also assist in turning with the iron handle or key, when the depth and length of rods require additional force to perform the operation. The workmen should be cautious, in boring, not to go deeper at a time, without drawing, than the exact length of the shell; otherwise the earth, clay, or sand, through which it is boring, after the shell is full, makes it very difficult to pull out. For this purpose the exact length of the shell should be regularly marked on the rods, from the bottom upward. Two or four flat boards, with a hole cut into the side of one of them, and laid alongside of one another over the drain, in time of boring, are very useful for directing the rods in going down perpendicularly, for keeping them steady in boring, and for the men standing on when performing the operation (No. 4, in Plate 17). The other implements used in cutting the drain are, besides the common spade and shovel, those represented in the Plate. The hollow spade, made of oak-timber, and scooped out in the middle, is used in soft peat soils, being light and easy to work with, and the edges preventing the earth from falling off when throwing it out of the trench. They are made of iron, in the same shape, also, for throwing out clay or tough soil. The crooked-handled spade or shovel, having the edges turned up, is well adapted for smoothing the bottom of the drain before laying the sough, and with which the workmen have less occasion to stoop. As the common opening of the sough is six inches square, a piece of wood of that size, and one yard in length, is very useful for laying in the bottom of the drain, and building the stones on each side of it, and which can be shifted forward as the workman proceeds in forming the sough.

Of the Horizontal Auger.

This instrument was lately invented by Mr. Haford, of Hathern, in Leicestershire, and is not yet come into general use. The advantages of it are in many cases considerable, by lessening the expense of otherwise cutting, and perform-

ing the work in a much shorter time. Where a drain or water-course has to pass under a bank, road, hedge, wall, rivulet of water, or for drying marl-pits, &c., it may be used to advantage in excavating a sufficient passage for the water without opening a trench. In laying leaden pipes for the conveyance of water, it is also useful in making a hole in which the pipe may be laid without opening a cut on purpose.

For tapping springs, or finding water at the bottom of a hill, either for the supply of a house, or for draining the ground, it may be used with success, as the water of the spring, when hit on, will flow more easily, and in greater abundance, through a horizontal or level, than through a perpendicular outlet.

The manner of using it is thus :—Suppose a lake, or pond of water, surrounded with high banks to be emptied: if the ground declines lower on the opposite side, find the level of the bottom of the water, and trace the level to the face of the bank where the perforation is to be made. There smooth the surface of the ground, so as to place the frame nearly level, with the auger pointing a little upwards. It requires two men to turn the handles at top in order to work it, which may be better understood by examining the Plate. When the auger or shell is full, the rods are drawn back by reversing the lower handle, and rods added at the joint when the distance requires. In boring through a bank of the hardest clay, two men will work through from thirty to forty feet in a day, provided there is no interruption from hard stones, which will require a chisel to be fixed on in place of the shell, and longer time to work through. If the length to be bored through is considerable, or longer than the whole length of the rods, a pit must be sunk upon the line down to the hole, for placing the frame when removed, and the operation carried on as before.

CHAPTER XII.

EXTRACTS FROM SOME OF THE AGRICULTURAL REPORTS OF THOSE COUNTIES IN ENGLAND WHERE MR. ELKINGTON HAS EXECUTED THE MOST REMARKABLE DRAINAGES, TENDING TO AUTHENTICATE THE ADVANTAGES DERIVED FROM HIS PRACTICE.*

I SHALL begin with Warwickshire, being Mr. Elkington's native county, and the one in which he first made the discovery.

County of Warwick, by John Wedge.

"Draining is, without doubt, the first step towards the improvement of all wet land; it has been practised with much success in this county for several years, but more particularly so since Mr. Elkington, a farmer in this district, introduced a method of draining boggy lands, by making deep drains, and boring at the bottom or sides of them through the different under strata, so as to tap the springs, and thereby, in many instances, cure large tracts of land with very few drains. The novelty of this practice here, and Mr. Elkington's mysterious manner in declaring he knew where, and in what direction, the different strata of the earth divided, and at what particular point an auger-hole might be bored, to lay dry this or that particular spring or well, were matters which attracted much notice, and occasioned great surprise; and it is but justice to Mr. Elkington to say, that in one class of bogs, &c. which abound as much as (perhaps more than) any other, he has not only had the honour of introducing the auger in this county, but the merit of laying effectually dry many large tracts of land."

County of Leicester, by John Monk.

"The most capital improvements have been made under the direction of a Mr. Elkington, who is supposed to be the first in that line in the world. After forming the drain, by beginning at the fall and working upwards, he makes use of

* These extracts are taken from the first reports transmitted to the Board of Agriculture; but in the second publication of them more information on this subject will be found.

a borer to find the spring, with which he generally succeeds, which has a wonderful effect in draining the land. It is said that he has a very quick and certain method of finding where the springs lie, peculiar to himself. By the use of the borer, Mr. Astley* had a piece of land drained without going into it, by the following circumstance:—Mr. Elkington was employed in draining a piece of land belonging to Mr. Richard Astley, which was separated from his brother's by a small river or deep rivulet. Mr. E. finding the spring at about sixteen feet from the surface (under the bed of the river), completely drained both pieces. I was informed that, some time since, Mr. Elkington was engaged in draining a piece of land near Lutterworth; and soon after he had found (some call it tapping) the spring, the inhabitants, to their very great surprise, found their wells all dry. After investigating the cause, it was found that Mr. E. had been the means of it, by cutting off the spring which supplied the town with water.

"I mention the above two instances merely to shew what a wonderful effect the borer has, and what a very capital instrument it is for draining, &c.

"I do not mean to say that Mr. E. is the only person that makes use of the borer; for there is such a very great spirit for this kind of improvement, that there are very few of the best farmers without this instrument. Mr. Elkington has so much business, that it is with great difficulty he is to be had when wanted."

County of Derby, by Thomas Brown.

"———— But every other method seems to bend to that practised by Mr. Elkington, whose practice is becoming every day more extensive, and seems to me the most effectual of all others for carrying off subterraneous waters. He lays a stone drain from three to six feet below the surface, in such a direction as to cut the source of the spring, and with such a declivity as to scour itself. Wherever he finds the source of the spring below the level of his drain, he bores, and with such judgment, that, to a stranger,

* Of Odstone Hall.

his auger seems possessed of the virtue of that rod with which Moses struck the rock; for the water immediately gushes out, and perhaps lays land that before was too wet to carry a sheep, sufficiently dry to carry the heaviest ox. This method is certainly effectual against springs."

County of Suffolk, by Arthur Young, Esq. Secretary to the Board of Agriculture, &c. &c.

"It will not be improper to hint, that there are two errors very common in the performance of this improvement. The first is, making the drains in, or nearly in, the direction of the declivity; whereas they ought always to be made obliquely across it: the other is that of marking out, and making numerous drains across the sides of springy hills, which might, in many cases, be drained completely with a single drain, judiciously disposed, according to those obvious principles upon which the celebrated drainer, Mr. Elkington, of Warwickshire, proceeds. No improvement can have greater or more immediate effects than this of draining; none that pays the farmer with more certainty."

County of Stafford, by William Pitt.

"Attempts have been made to tap springs, by boring into them, by Mr. Elkington *and others*, and sometimes with success."———

Mr. Pitt, in speaking of the improvements in Fisherwick Park, says,

"Here the genius of a Brown, aided and seconded by the munificence of the noble owner,* have conspired to render a dreary morass one of the most delightful spots in nature, and have in a great measure succeeded: which success is still further heightening by the improvements of Mr. Elkington, in the interception of springs, and the discharging of stagnant water."

* Marquess of Donegal.

LIBRARY ILLINOIS

County of Worcester, by W. J. Pomeroy.

"In speaking of under-drains, it may be thought right to mention, that various experiments have been made at Ewell Grange, the seat of the Earl of Plymouth, and in that neighbourhood; but that by boring after Mr. Elkington's method deserves to be most particularly noticed, which, indeed, in such situations (viz. low, fenny, or boggy lands), seems to supersede the use of every other."

County of Somerset, by John Billingsley, Esq.

"The great skill of draining land consists in cutting off the water at its source. One deep drain, judiciously placed, will frequently preclude the necessity of any other; in most instances, such a drain should be near that part of the declivity from which the springs issue. This depends on the position of the clayey substratum, and on the height of the reservoir from whence the springs are fed. A judicious survey of the adjacent land, and liberal use of the *borer*, are necessary preliminaries to a cheap and effectual remedy for wet lands; and there are few men in the kingdom possessed of equal skill in this department of agriculture with Mr. Elkington, of Warwickshire, whose fame is not confined to the county in which he lives, but is known and acknowledged in many parts of the kingdom."

Extracts from the "Annals of Agriculture," by A. Young, Esq. &c. &c. Vol. XVI. Anno 1791.

"Aug. 5.—Rode to examine some works carrying on under the direction of Mr. Elkington, a singularly able drainer, whom I shall have more occasions than one to mention. * * * The chief object of our ride was to view Mr. Elkington's works, who, we were informed, was engaged by some of the owners of these mills,* to bring them more water, by draining some boggy spots from which

* Near Sutton Coldfield, in Staffordshire.

the springs arise. We viewed his trenches for this purpose; it seems that this most ingenious operator had contracted with the millers to be paid only in proportion to the additional quantity of water he procured for them. As we viewed his drains, and the general declivities of the wastes around, a question arose amongst us, upon the possibility of procuring more water by any drains, or cuts, or boring, than flows already in a more diffusive manner through bogs; except by bringing water to take a direction on one side of a hill, which, in its natural course, flows out on another side. * * * But Mr. Elkington's practice is remarkable in one circumstance, *and differs from any drainer I have yet known.* From distance to distance at the bottom of his surfs,* which are of various depths, from three and four to six and seven feet, he bores with a common iron boring-rod, five or ten lower, and in doing this, often finds the water rise quickly in the hole. By this operation, it should seem, that he has Mr. Bakewell's† idea in contemplation; and it is to be noted that by this practice he, in many cases by a single drain, lays lands dry that were not at all in the contemplation of the person who employs him, even to a considerable distance. Supposing springs to lie in strata, nearly on a level, and to communicate from side to side of the largest hills, in such case it does not seem at all improbable, but that by draining and boring deeply on one side, you may procure more water than came before, by diverting it from the usual course; so that by carrying on works of this sort on one side of a mountain, the other side, at some miles distance, may be drained. Thus the millers on one side of a hill may pay Mr. Elkington for bringing water to their dams, and the millers on the other side of the hill prosecute him for depriving them of theirs; which, it must be confessed, would be a laughable litigation. * * Such works, whatever their operation, causes, and consequences, have infinite merit, and do great credit to the talent of this very ingenious and useful man, who will have the merit, wherever he goes, of setting men to think."

* Or Sough, the conduit, or bottom part of the drain, formed with brick or stones.

† See "Annals of Agriculture," Vol. XVI.

"The 6th.—To Ashby-de-la-Zouch; called in our way on Mr. Marshall, to view a bog of several acres, drained by Mr. Elkington, which he effected with his usual success.

"This bog was occasioned, as they commonly, or rather always are, by springs, which he pierced into by means of a deep drain, boring at the bottom of it, as above described; the surf, in this dry season, runs no inconsiderable stream. The whole is now under oats, a very fine crop, on land which before was of no value whatever. * * * Mr. Elkington has been employed by Mr. Knowles* to drain the slope of a hill poisoned with springs; in every instance of his draining I hear some new circumstance to prove the sagacity and ingenuity of this skilful operator, who may be termed an engineer of a new order. The crown of the hill above Mr. Knowles's wet fields is all dry, sound, gravelly land, in which are no signs of springs, because pervious to water in its level; but when these springs came to the fields in question, which are clayey, they rise to the surface proportionably to the quantity of clay which impedes their progress; in this case he found, by taking the levels, that springs on the other side of the hill, in a clayey spot, at the distance of some hundred yards, were exactly on the same level as these passing under the gravel on the elevation, and thus breaking out where the passage was obstructed by variation of soil. And he pronounced, that when this is the case, one surf, skilfully marked, will drain a variety of different, and even far distant, fields; and he recommends, in such cases, to wait after the first drain is made, to let its operation take place, for six months, or even a twelvemonth; in which time it will be found how far the effect has taken place: if more are wanted they can be made. When springs are brought in this manner from a distance, there is no doubt but he brings more water to a place than flowed in it before. The great skill is to know where to bore. The surf, or French bricks, which he uses, are eight shillings a thousand more than common ones."

* Of Nelson, in Leicestershire. In a certificate sent to the Board of Agriculture, Mr. Knowles says, that this land, by means of Mr. Elkington's drains, was rendered worth 30*s.* or 40*s.* an acre, which before was not worth half-a-crown.

In a treatise lately published, "On the Necessity and Advantages of Care and Economy in collecting and preserving different Substances for Manure," by Thomas B. Bayley, F.R.S. is the following observation:—

"It may reasonably be expected, that at no very distant period, the peat-mosses of Great Britain and Ireland will be drained, and brought to the highest state of fertility. Their present superabundant moisture renders them not *merely* unproductive wastes, but extremely injurious to the drier lands in their vicinity. The invention and energy of a Wakefield* and an Elkington, in reclaiming and improving mosses, cannot fail to excite a general imitation of the very successful processes by which they have rendered these bogs productive of plenty; with the additional happy effects which those improvements never fail to produce on the *climate*, *temperature*, and *vegetation*, of all the countries adjacent to them."

Subjoined is part of a letter received from Charles Townley, Esq. of Townley, in Lancashire, respecting Mr. Elkington's method of draining, and the improvement made on the ground, by means of his drains.

—— "Respecting the mode of executing these drains, it differs from the common practice of making hollow drains, only by their being cut much deeper, and by boring with an auger, either to increase the runs of water from the springs, when they are arrived at, or to give them vent when they lie too deep for the spade to reach them. Mr. Elkington's art, or knowledge of draining, lies, as you must know, in judging of the precise place where the pernicious springs can be caught, and in carrying them off in the cheapest and most advantageous manner. The mere plan of a drain can give little insight into this kind of knowledge: I should think, the best mode of conveying the system, by plans, to the conceptions of others, would be to compose sections of the different circumstances that most generally occur in the various strata and runs of water below the surface of the earth, and

* Of Liverpool. Mr. Wakefield has lately made wonderful improvements upon the great Trafford Moss, near Manchester, in Lancashire.

of the most proper situations of the drains that are to catch them. I will only repeat, that those drained *boggy lands* that have had the proper manure laid upon them, are not only made dry, but the herbage produced on them is become excellent, from having been, previous to the drainage, of very little value; and those drained lands which have as yet received no manure, are rendered equally dry, and the coarse and useless herbage with which they were wholly covered is visibly giving way to better grass. The proper manure will soon be laid on them; after which, I am persuaded, the whole herbage will be excellent: the drains were only finished last year. (Signed) "CHAS. TOWNLEY.

"*Townley*, 28*th Sept.* 1796."

Copy of a Letter and Certificate from Mr. John Maughan to Sir John Sinclair, Baronet.

"*Hinckly*, 25*th Oct.* 1796.

"Sir,—I am extremly sorry at having taken so long a time in returning the certificate you wished me to send; but I waited to see the effect of a drain I had set out for Mr. Jennings, of Harlington, Bedfordshire, a nephew of the late Mr. Whitbread's, or I should have sent it sooner. The land I drained for him, had, about two years ago, been attempted to be drained in the common mode, and a considerable sum of money had thereby been expended to no purpose, as the land, at the time I undertook to drain it, was as wet as ever. I have the satisfaction of saying it is now the driest land on the estate, and made so at an expense which does not exceed one twentieth part of what it had formerly cost, by attempting the common mode of draining.

"I am, Sir, your obedient humble Servant,

(Signed) "JOHN MAUGHAN."

Copy of the Certificate.

"I, John Maughan, of Luton, in the county of Bedford, land-surveyor, late steward to Thomas Powis, Esq. M.P. do hereby certify, that, in consequence of a recommendation

from the Board of Agriculture, I waited on Mr. Elkington, who very readily communicated to me the principles of his art of draining land, which I have since practised myself with great success, and to the satisfaction of those who have employed me. And I hereby farther certify, that I have found Mr. Elkington's mode of draining of the greatest public utility: that I have seen land of little or no value, when drained on Mr. Elkington's principles made worth forty or fifty shillings per acre, and producing the richest crops both of corn and grass: in short, that no mode of improving wet land equals it for public utility.

"Witness my hand, this 25th day of October, 1796."

Besides the above, many other communications and certificates, testifying the great advantages that have been derived from Mr. Elkington's practice, and what are likely to result from the knowledge of his system being generally understood, might have been added; but as most of these have already been made public by the Board of Agriculture, in a former paper on that subject, what I have inserted here may be sufficient to convince the public of its utility.

PART II.

ON HOLLOW AND SURFACE DRAINING IN GENERAL; PARTLY DRAWN UP FROM COMMUNICATIONS TRANSMITTED TO THE BOARD OF AGRICULTURE.

This being a part of the draining system not coming within the limits of Mr. Elkington's practice, and founded on principles different from those that are applicable to the drainage of bogs, and other swampy ground injured by springs, I have thought more proper to add it as a *Second Part*, than to have incorporated it with the preceding account.

When the wetness of a field arises from rain-water that cannot sink through a tenacious soil, and must, if there is no declivity, remain till evaporated, the principles which govern the practice of Mr. Elkington's art are not applicable. But,

In all cases (and such are very numerous) where the wetness proceeds from springs, a farmer ought certainly to examine his field carefully, in order to ascertain whether the evil proceeds from the *above cause only*, or whether it proceeds from springs. If from the latter, he should endeavour to discover if such springs are distinct and unconnected, or whether they do not flow from some *main one*, which, being cut off, would drain a considerable tract of land below the spot where it rises, as has been explained and exemplified in the latter part of Chapter III.

From want of due attention to this necessary discrimination, it is very common in Essex, Suffolk, and other counties where draining is very generally performed, to see many superfluous drains marked out in directions where they can have very little effect, and where a single one, well-directed, would have completely dried the field. As the expense, which might thus be saved, is an object of consequence, too much attention cannot be paid to the inquiry.

SECTION I.

On the Antiquity of the Practice of Hollow-Draining.

That the Romans were not unacquainted with most of the modern methods of hollow-draining, appears from all their writers *de re rustica*. Cato, Palladius, Columella, and Pliny, mention them particularly, and describe some circumstances which have lately been considered as modern improvements. Upon strong tenacious land, where the water could only be received at top, they preferred open drains; on other soils, where the water could be drawn equally from both sides, or could rise from the bottom, they used covered ones. They knew the propriety of directing them obliquely across the slope of the field, a point in which modern drainers are often erroneous. Their general depth was from three to four feet, filled half way up with small stones; for want of these, with willow poles, and even with the spray of wood twisted into a rope; one of the latest practices with straw that has taken place in England. Of that material, also, the Roman farmers availed themselves, when others were wanting. The ends of their drains they were careful in fortifying with larger stones, in form of bridges, and the mouths, or outlets, were laid in masonry, a circumstance in which Mr. Whyn Baker, of Ireland, thought himself original.

From the depth, it appears that their drains were designed to carry off the water of springs, as well as that caused by rain on a flat or retentive surface soil; for both which they were, in some cases, equally well adapted.*

To the proper direction of the water-furrows, in order to convey all surface water into the drains, and to the clearing and cleaning out of the ditches round the fields, they paid particular attention. These circumstances are sufficient to prove that the Romans understood the business of common draining in great perfection, and that our best cultivated counties had little to boast of in this respect, in superiority

* The passages of the ancient writers on this subject are quoted and translated by Mr. Dickson, in his "Husbandry of the Ancients," vol. i. p. 358, where the reader may see the details at large.

to the ancients, till Mr. Elkington made the discovery of a method with which they were wholly unacquainted. The best of the French writers on agriculture, De Serves, who wrote in 1600 his *Theatre d'Agriculture*, describes hollow drains particularly: they were filled with stones.

SECTION II.

When first used in England.

It would demand a very careful perusal of all the earlier writers on husbandry to ascertain when this practice was first introduced; but a circumstance occurred in Sussex, which shews that hollow-draining was in use long before any mention would be found of it, were such authors consulted, as no notice of it occurs in Fitzherbert or Norden.* In 1770, Mr. Poole, of that county, informed a farming traveller, "that near one hundred years ago, a very large oak, two hundred years old, was cut down at Hook. In digging a ditch through the spot where the old stump was, on taking up the remains of it, a drain was discovered under it, filled with alder branches; and it is remarkable, that the alder was perfectly sound, the greenness of the bark was preserved, and even some leaves were sound. On taking them out they presently dropped to powder. It is hence very evident, that under-ground draining was practised three hundred years ago in this kingdom. We find, also, that alder is, of all other wood, the best for filling drains. Probably no other, except aquatics, would endure nearly so long. Bushes are generally used, but sallow or willow probably better."†

The Board of Agriculture has been informed by Richard Preston, Esq., one of its correspondents, that land-draining, according to the present practice, is not of more than forty years standing in his neighbourhood, in Essex.

This deserves inquiry; for it is generally supposed to have been used there long before such a period.

* Fitzherbert wrote his book of husbandry in 1534.

† Eastern Tour, vol. iii. p. 141.

SECTION III.

Nature of the Moisture, or Wetness, against which they are chiefly used.

Springs that proceed from water at any considerable depth in the earth, or which break out, from the variation of certain strata, in hills, which demand deep cutting, and the use of the auger, to work their cure, according to Mr. Elkington's mode of draining, have already been treated of. Hollow drains that come under the present description, are chiefly used to correct that wetness of soil which results from rain; and which, from flatness of surface, or its retentive quality, stagnates, to the injury of both soil and crops. This is the most general nature of the evil which these drains are intended to remedy; but by no means exclusively of that caused by *land* springs, whose seat, apparently, is not below their depth. The wetness proceeding from such is, in some cases, removed by these drains, when deep enough cut, and properly directed; but in many others, from ignorance in the drainer, great sums of money are thrown away, for want of attending properly to the nature of the evil, and of distinguishing betwixt *surface water only*, and the oozing of *land-springs*.

SECTION IV.

Of the Soils on which they act, and of those on which they have been found to fail.

In soils that are so tenacious as to retain water on the surface till evaporation carries it off, such as are found in Sussex, Surrey, and in many other counties, this method of draining has been tried, and found entirely to fail. The cause of this can easily be accounted for. Very stiff clay will hold water *like a dish* (the expression of the farmers in those counties who have attempted to drain such soil); and, consequently, the small portion of water which each drain will carry off, is only what falls immediately above it, or what it can receive at top, when the ground on each side has a descent towards it.

The water being all *on the surface* cannot find its way into them. If they are on a declivity the water will run over

them, as it does over any other part of the field; and if they are in a hollow it will stagnate even above them, and will be mostly exhaled before any quantity of it subsides into them. This is, therefore, a more expensive soil to drain, requiring a greater number of trenches, and these very close together, than any other soil whatever. Open trenches, with the ridges and water-furrows properly formed and directed, are the only method whereby its drainage can be effectually accomplished.

It is necessary to lay it up in ridges properly placed, and to cut *small open drains* across the ridges, where requisite, communicating with each other, and with the furrows: and thus all the water-furrows operate as drains. The water, as it falls upon the ridge, immediately makes its way into the furrows, and runs along them, while there is descent; and if it is stopped in any of them, by the ground rising, is conveyed by the drains across the ridges into some other furrow where there is a descent, along which it marks its way into some ditch or water-course at the extremity of the field.*

In Essex and in Suffolk, where it has been found advantageous, the soil is a wet poachy loam, more or less mixed on the surface with vegetable mould; under that, in some places, a *raw hungry loam*, and in others a clay marl.

On these soils the effect is very great; for the upper stratum, where the moisture is chiefly lodged, being in some degree porous, the water is easily extracted from it, by means of the drains. The under-stratum being also of a retentive quality, their depth does not require to be great.

When Mr. Young, of Clare, who has had great experience in this mode of hollow-draining, observes, that the improvement by these drains is great on clay soils, he certainly means soils of this description. "I know from experience, that in clayey soils it will answer perfectly; that it is the least expensive and the most expeditious, as well as most durable, improvement of any in the whole system of agricultural economy."—This will be further treated of in Sect. XVIII.

* It is obvious, that laying up such land in ridges, and cutting drains in proper places, may be of great use, but will not effectually remove the wetness; as the soil, from its nature, will always retain too great a proportion of moisture. It is necessary, therefore, to change the nature of such soil by frequent culture, and the application of manures, which will, in a great degree, lessen the power of retaining water.

SECTION V.

By what Rules their Direction is marked.

For many years, probably for more than half a century, and possibly during a much longer period, the farmers did not make a proper distinction, in fields that had a declivity, between tracing their drains *with the slope*, or directing them *obliquely across it.* Large tracts have been drained, or have been meant to be drained, in the former way, and many, even to this day, are guilty of the same error; but the best farmers are now attentive to so important a point, and studiously mark the direction of their drains obliquely. They are also careful to give them just the fall sufficient to carry off the water in a gentle, and not a rapid, current; by which means they are less apt to choke, or *blow up,* as it is sometimes called, whereby spots in the field have, apparently, an artificial spring formed.

Upon fields, level, or nearly so, great numbers of which are found in the eastern counties of England, it has been a common practice (although an expensive one), if the wetness proceeds solely from rain, to mark the drains regularly at a rod,* a rod and half, or two rods, asunder, across the land, from ditch to ditch; or if the drains, from any small inequality of surface, will flow only at one end, then to stop short, or discontinue their length on one side of the field, as soon as the ditch operates in laying it dry.

Where the slopes of a field vary, and fall in different directions, the farmer should attend to such variations, and direct his drains so as to cross obliquely the upper side of each declivity.

It is a general rule, not to conduct too many drains to the same mouth or outlet; for if much water flows in any drain, from having thrown many lateral branches into one main drain, the latter must not only be made larger and deeper, but will even then be liable to fail; and a failure in that case affects so much a larger space of ground, by im-

* Sixteen and a half feet.

peding the course of so many other drains. On this account, it has been found better to make the drains detached, rather than to connect too many of them together, which occasions much water to be conducted to one mouth.

Cases will however occur in which, from the position of the ground, it may be found necessary to join several side branches (wings) into one main drain, On this subject, Mr. Vancouver, in his Agricultural Report of Essex, has the following judicious remark :—

" If the field proposed to be drained lies greatly upon the descent, every care should be taken to make the drains bear sufficiently horizontally, in the first place, to prevent a too precipitant fall of water, by which the bottoms of the drains would be worn uneven, and a temporary obstruction occasion them *to blow ;* and, secondly, because the more perfectly horizontal is the field, so that it lies level free, and affords a sufficient fall for the water, the less occasion will there be for the same number of drains as would be required upon a soil of equal closeness upon the side of a hill. The drains in the field that lies nearly level, drawing equally well upon each side ; whereas those on the hang of a hill, drawing only from the higher sides of the drains, and consequently requiring them to be made much nearer or closer together."

SECTION VI.

Season for executing the Work.

On this point opinions vary ; some prefering winter, and others summer,

When a great quantity of work is to be done, all seasons of the year, free from sharp frosts, must be made use of ; and this is usually the case, when a farmer enters on a lease to a farm which has not been drained, or which requires to be done a second time. Stubbles are done in winter, and fallows in summer ; but when a single field or two are only to be done, the farmer may choose the most convenient season. Many excellent farmers would not do it at any other time than summer, from being then able to execute the cuts in a cleaner and neater manner, and free from that kneading

and plastering which takes place in winter, and which, they think, tends to prevent the flowing of the water from those minute and imperceptible veins and insterstices of the soil through which the water percolates. They have further remarked, that opening the earth in a dry season gives a tendency to drain it, as the particles of the soil, after being separated and well dried, will not so easily unite again; whereas, the kneading in winter tends to increase tenacity where it is most to be avoided. Farther, that carting on the fields in winter, to bring on stones or other materials, is more difficult and dangerous than in summer.

In opposition, however, to these ideas, Mr. Young, of Clare, in Suffolk, is of a contrary opinion:

"I never land-drain (says he) in summer: two inconveniences attend it; the increase of labour in a clayey soil when hard and dry is very considerable, and the want of leisure, and when good labourers are scarce."

The want of labourers, in some places, may be an unanswerable objection, but the dryness is not; for if the previous furrows opened by the plough, or last course of ploughing on arable land, be not left to dry, but the spades follow directly, after a little rain there will be moisture sufficient to make it work freely. Many good drainers prefer executing the work when the land is under *a layer*, *i. e.* sown down with grass. Lord Petre, on this, observes, that the plough for opening the previous furrows works better on a layer: —

"I prefer a lay, if laid down level, as I have a plough on a very simple construction, with which, and six horses, I can plough from ten to twelve inches deep, and lay the furrows as regular as a man can with a spade, so that after the ditch is digged and filled, the furrow can be put into its place again and rolled with a large roller quite level; and then I dig but one *spit* with the bottom land ditching-spade, fourteen inches deep. The expense, 2*s.* 8*d.* per 20 rod, the digger returning the furrow to its place. I also use this plough on fallow; but it does not answer so well, as the moulds fall into the furrows. The expense of digging on fallow is 1*s.* 2*d.* per rod."

When the ground is in summer fallow, is certainly the best time for casting drains that are only for carrying off surface-water, as the distinctions betwixt the wet and dry

parts of the field is then easily perceptible, and any prominent inequalities of surface may then be more easily levelled or reduced, by paring off the heights and adding to the hollows.

SECTION VII.

Manner in which Drains are partly opened by the Plough.

The method practised by Mr. James Young, of Clare, which he has described himself, from very ample practice, is deserving of attention. He says, "When I have marked the drains in a field (usually a rod asunder), I draw two furrows with a common foot-plough, leaving a *baulk* betwixt them about fifteen inches wide; then, with a strong double-breasted plough, made on purpose, I split that *baulk*, and leave a clean furrow fourteen or fifteen inches below the surface; but, where the depth of soil requires it (for I like to touch the clay), by a second ploughing I sink it to eighteen or twenty inches; it is then ready for the land ditching-spade, with which I dig fifteen inches deep a drain as narrow as possible."*

The method followed by some good farmers, who do not possess ploughs made on purpose for the work, is this: with their common plough, drawn by four or five horses, and usually stirring about four or five inches deep, they turn a double furrow, throwing the earth on each side, and leaving a *baulk* in the middle. This *baulk* they raise by a second *bout* in the same manner; then they go in the open furrow twice with their common double breast-plough, getting what depth they can; after this, they shovel out all the loose mould and inequalities, to the breadth of about a foot, and thus, having gained a clear open furrow, the depth varying according to the soil and ploughs, but usually about eight or nine inches, they dig one *spit* with a draining-spade, sixteen inches deep; thus gaining, in the whole, twenty-four or twenty-five inches. But, as this depth is seldom sufficient, when necessary they throw out another, or even two other *spits*, which makes the whole depth from thirty to forty inches.

* Annals of Agriculture, vol. viii. p. 164.

SECTION VIII.

Depth and Width.

The depth is various, according to the nature of soil, the situation of the field, the expense the farmer is willing to incur, and to a diversity of other circumstances. Many years ago, three feet was the common depth in most soils; but, for twenty years past, they have seldom exceeded thirty or thirty-two inches, and the number that are cut only twenty-four or twenty-six, much more considerable.

Main or receiving drains are always a little deeper than the others, having more water to convey, and farther to carry it. The deeper they are dug in pervious soils, the farther they will operate in reducing the moisture to a level, where it can less injure vegetation; but when the spade reaches an impervious soil, through which water will not percolate, there is no occasion for making the trench any deeper. A few inches, however, in the clay, as a safer channel for the water, is of advantage.

One general rule is never to be departed from, which is, that the depth must be sufficient to prevent the impression of the feet of cattle from affecting the position of the materials used in filling them. This must particularly be observed of horses walking in the furrow while ploughing, as they then tread four inches, and perhaps more, below the surface of the ground; add to these four inches nine or ten more for the materials, and when the drains are only twenty-four deep, there will be nine or ten inches of soil to bear the weight of the horse in the act of ploughing. This, as the earth has been stirred, seems certainly too little, and should apparently ascertain that twenty-four inches is by no means a sufficient depth. If, by going thirty inches down, a tenacious soil is not too deeply entered, a greater depth in a more porous one is not only requisite, but ought to be greatly preferable.

In all the modern drainages in the eastern counties, the farmers have been very solicitous to cut them as narrow as possible; by which means a great saving is made in the materials used for filling them, such as bushes, poles, spray, or straw; but if brick or stones are used, of course this rule cannot be adhered to. However, there is no occasion for the

width being greater than one foot, if the stones are only coupled at bottom, or thrown in promiscuously, or more than sixteen inches if laid in the form of a conduit. Whatever the depth of materials be, the mould that covers them to the surface should never be less than one foot thick, or rather more, in all tillage fields. In pasture land, gravel, if at hand (especially if the soil is very tenacious), is preferable to the mould thrown out, which may be spread in any adjoining hollow.

The depth and width, &c. marked in the Plate, is the proportion that ought to be adopted on all land that is wet from surface water, or from its stagnation in a porous upper soil.

SECTION IX.

Tools Employed.

The instruments which have been long in common use in the eastern parts of the kingdom are extremely simple.

While the depths of the drains were more considerable than at present, three spades were in use, to succeed one another, lessening in breadth gradually, in such a manner as to form a regular contraction to the bottom; but, of late years, cheaper and easier methods have been pursued. By previous ploughing all the spades, except the lower one, have been laid aside; and where a greater depth than common has been required, not more than two have been used. The scoop, which is pushed or drawn along the bottom of the drain, to clear out the loose moulds, and prepare it for the materials used in filling, varies, in size and breadth, according to the width of the drain. The draining-spade, which is also of different sizes, is represented in the Plate.

SECTION X.

Of Digging Hollow Drains.

The preceding circumstances point out the manner in which these drains are for the most part dug; but there is a material difference in the truth and accuracy with which they

are executed, according as a workman is accustomed to the business, and skilful or awkward in handling his tools. The work is almost universally done by measure, at so much a score rods, which, as in similar cases, induces the men to earn as much as possible. They require, however, close attention, to see if they keep to the depth contracted for, and that they deposit the earth so as not to fall in in the act of filling, especially as the surface soil should (on one side at least) be kept free from the clay or lower stratum.

In filling, more attention is necessary if done by contract, which will be afterwards explained.

SECTION XI.

Opening Drains by the Plough only, &c.

The Society for the Encouragement of Arts, Manufactures, and Commerce, gave a bounty, about twenty years ago, to Mr. Makins, of Suffolk, for having invented a plough to cut hollow drains.

There was merit in the idea, but it has long since been entirely laid aside, both in Suffolk and Essex.*

Another plough, to answer the same purpose, was invented by Mr. Arbuthnot, of Mitcham, of which an account is given in the *Eastern Tour*, with a plate and measurement of it. And lately, the Society of Arts have made several trials with a plough for the same purpose, called a *mole* plough, of a singular construction; the intention of which is, by considerable force, to draw a pointed circular iron, at a given depth, through the earth, which shall form a pipe in it, not to be filled with any materials; but in the expectation, as it is said from experience, that the water will flow freely through the soil it has loosened, to a depth below the roots of the grain, and will find its way by filtration, into the furrows.

It is imprudent too readily to suppose a limit to human invention; but it may be observed, that the probability of an *effective hollow-draining plough* being invented, that shall work so much cheaper than the spade, as to become an

* In Bailey's "Advancement of Arts" there is a plate and explanation of it, p. 6.

object of economy, is not flattering: none hitherto tried seem fully to answer this idea; but there can be no difficulty in making one to prepare for the narrow draining spade, to take one spit at bottom. The repeated ploughings or shovellings with common tools are expensive, and might probably be executed in a cheaper and more expeditious manner by an open drain plough.

How far that invented by Mr. Knowles, and rewarded by the Society of Arts, would at a sufficiently cheap rate answer this purpose, has not been sufficiently ascertained. But it is obvious that, from the force and number of horses or oxen requisite to work them, ploughs calculated for this purpose will never come into general use.

Another invention for draining land, in Essex, is thus described in the Agricultural Report of that county: — "The author of this experiment has constructed, and uses a draining wheel of cast iron, that weighs about 4 cwt.; it is 4 feet in diameter; the cutting edge, or extreme circumference of the wheel, is half an inch thick, which increases in thickness towards the nave or centre, and will, at 15 inches deep, cut a drain half an inch wide at the bottom, and four inches wide at the top. This wheel is so placed in a frame that it may be loaded at pleasure, and be made to operate to a greater or less depth, according to the resistance made by the ground; which thus cut in the winter, the wheel tracts are then either filled with straw ropes, and lightly covered over, or left to crack wider and deeper during the ensuing summer. The fissures are then filled with twisted straw or bushes, and covered lightly with some of the most porous earth that may be most conveniently at hand; and thus upon the grass, or ley land, are hollow drains formed at little or no expense, and which, upon trial, have been found to answer extremely well."

This draining wheel is also described in the Annals of Agriculture, where it is said, that twelve acres have been done with it in one day; but neither the expense of the machine, nor number of horses required to draw it, has been stated. It works or cuts best when the land is wet and soft.

SECTION XII.

Materials with which they are filled.

In respect to the materials for filling the drains, the farmer must be guided by circumstances of situation, &c.—Those most commonly used, are, 1, stone; 2, wood; 3, straw and stubble; 4, heath or ling; and 5, bricks made for the purpose.

If stone taken from quarries is to be used, and the drain formed like a conduit at bottom, the trench is made wide enough to contain two side stones about six inches asunder, and the same in height, with a cap or flat stone laid over, which covers and secures the cavity through which the water passes.* These drains are more expensive than when the stones are thrown in promiscuously, but are the only ones applicable to springs, which may be prevented from injuring large tracts of land by cuts comparatively short. But in Essex, and the other eastern counties, when hollow drains are filled with stones, it is usually with flints from chalk, or with stones from gravel pits, or gathered off the fields.

Very small stones do not answer well for any but very short drains, in which little water is conveyed; and if of any size, require a greater width at bottom than wood or straw, and consequently renders the expense of cutting greater.

Whether the stones are large or small, they should be very clean, and free from any clay or earth that may adhere to them, and put in carefully, so as not to tumble down any of the earth of the drain, which might be apt to choke up the interstices betwixt them.

Upon the subject of filling drains with wood, Lord Petre thus expresses his opinion:—

"The drains filled with wood, and covered as usual with straw or rushes, are preferable to stones or any other kind of materials; the reason is, as the wood decays the water continues to pass. When filled with stones, and the drains stop up, which must be expected to take place in time, the earth becomes quite solid round the stones, and as they do not decay, the filtering of the water is for ever obstructed: not so when bushes or wood are used; continual filtering and

* Another mode of laying the bottom stones is described in Sir H. Fletcher's communication. Section xviii.

draining are then for ever to be perceived; and by repeating the operation a second time, cutting the drains transversely of the old ones, the benefit of the filterings through the rotten wood is secured, and the spewing up of old, broken, and damaged drains corrected and carried off. Moreover, as bushes form a much greater number of cavities than either stones or poles, they are less able to stop up, and encourages filtering more than larger and more solid bodies."——"A load of bushes containing one hundred and twenty fagots will do about three hundred and sixty rods; and a load of straw containing one hundred and twenty bottles, the same; the load of bushes is generally worth about 14*s.*, and the straw 18*s.* per load. I therefore calculate this expense about 12*s.* per acre, ditches a rod apart."

Richard Preston, Esq., of Blackmore, a correspondent of the Board, prefers, on twenty years' experience, black thorns to every other material for filling.

There is also another method of filling with wood, by suspending the fagots or bushes upon cross billets set on end in the bottom of the drain, as represented by No. 5, in the Plate.

This kind of drain has been successfully practised in Berwickshire, where it is said to have continued running for thirty years.

It has also been attempted at Livingston, the seat of Sir W. Cunninghame, but is not approved of there; for it is said, that the feet of the cattle, in ploughing, went down and deranged the billets that supported the brushword, and consequently put a stop to the discharge of the water; but this has been owing to the want of a sufficient depth of earth above the wood, which was not more than six inches.* This kind of drain is, however, much recommended by the writer of the Agricultural Report of the County of Caermarthen, in Wales. He says, "The completest method I have yet known is to cut the strongest willows, or other aquatic brushwood, into lengths of about twenty inches, and place them alternately in the drain, with one end against one side of the bottom, and the other leaning against the opposite side. Having placed the strong wood in this manner, I fill the space left between them on the upper side with the small

* Sir W. Cunninghame imported this mode of draining from Richmond Park, near London, where it has been very much practised.

brushwood; upon which a few rushes or straw being laid, as before mentioned, the work is done. Willow, alder, asp, or beech boughs, are exceedingly durable, if put into the drain green, or before the sap is dried; but if they are suffered to become dry, and then laid under ground, a rapid decay is the consequence. I have seen willow taken out of a bog after lying there thirty years, and its bark was as fresh and sappy as if it had been recently cut from the hedge; and it is well known that beech laid green in the water will continue sound for any length of time."

There is another method preferable to these, and requiring less wood: it is to fix in at every foot distance a stick, in manner of a hoop or semicircular arch; and along these to lay the longer poles or branches longitudinally. This will form a secure vacuity below, and an arch capable of supporting any weight of earth necessary above it. From its known durability in water, and being sufficiently pliant, the young branches or prunings of larch are well adapted for this purpose.

Mr. Majendie is of opinion, that wood of eighteen years growth is much more durable than that which is ten or twelve.

Respecting filling drains with straw, the following observations by Mr. Vancouver, in his Report of Essex Husbandry, merit attention: —

"When the soil is a very close and retentive clay, the drains should be made proportionably near to each other, shallow, and filled with straw only, it being totally unnecessary to use wood, or any more durable material, upon land where the sides of the drains are not likely to crumble in. Upon a soil like this the drains should seldom exceed the distance of three or four yards apart, and twenty inches deep, or such a depth as may be the most conveniently obtained, by first opening the drains with the plough, shovelling the bottom of the lowest furrow, and then digging one spit only with the land ditch spade; and which, materials included, will cost about 2*s.* 6*d.* per score rods.

"Drains formed in this manner, through the tough and retentive clays, will be found, in a short time after the work is finished, to have formed over the straw with which the drain was filled, an arch of sufficient strength to support the incumbent weight of the soil, and the casual traffic of the field. In twelve or eighteen months, it may be observed,

that the straw, being of one uniform substance, is all rotted and carried away, leaving a clear pipe through the land in every drain, into which the passage of the water may have been much facilitated, by a due attention to the filling of the drains with the most friable and porous parts of the surface the field might have afforded."

The latest and best improvement in filling hollow drains with straw, is that of twisting the straw into a rope, described in the following passage concerning some improvements in Essex:—

"The most prominent feature of his improvements is, a new method of filling land drains. The common practice is to tread in loose straw; but Mr. Bedwell has invented a method of winding it into a hard rope, as large as a man's arm, which he forces to the bottom of the drains, and finds, from experience, copied successfully by his neighbours, to convey the water off more readily, and to have much longer duration; at the same time, the quantity of straw consumed is not increased, and the operation of filling accelerated. After the cattle have picked it over, he finds the straw tougher, and in better order to wind, than when quite dry and fresh." The figure in the Plate is a representation (not of Mr. Bedwell's), but of a more simple movable machine, for twisting the ropes to be used in the same manner.*

The next material to be noticed is bricks made for the purpose. These have already been described in Chap. III. and Plate 12.

They are effective, but expensive, and not so well adapted for surface-draining, except for conducting away springs, in which work a small extent of drains may answer for a large tract of land. These bricks are made of various shapes and sizes, but generally have a semicircular cavity for the water to flow in, and rest, in stiff soils, on the ground; in soft soils, upon each other, forming a circular tube, or on common bricks, as a foundation.

In Essex, and other counties, pipes of clay, about eighteen inches long, with an opening of three or four inches diameter, are burnt and applied to similar purposes, but are best calculated for conveying any small rill of water or spring for the supply of a house, &c.

* See Foote's Report of Middlesex.

The following judicious remarks respecting the arch brick, represented by No. 3, in Plate 16, have been stated by the writer of the "Agricultural Survey of Salop:" I have made what I call a brick arch for that purpose (of draining), full an inch thick, and a foot long, nearly of the shape of a ridge tile, but being not more than five inches wide at bottom, and six inches semi-diameter. It cannot possibly be used in building; but such having been made at a brick-kiln, the excise officer thought them taxable, and charged them 2*s.* 6*d.* per thousand, as common bricks. Two members of parliament did me the honour to represent this at the proper office in London, in hopes of getting off the tax, which has not yet been done. This has checked the use of them; for nothing can be more irksome than a tax upon a material to be used in an essential improvement upon land; besides, there can be no more lawful pretence for taxing the arch brick of that shape, than there is for taxing the earthern pans and cups at a pottery. These arches may be made when common bricks are at 15*s.* per thousand without tax, at about 30*s.* per thousand, which will lay a cavity of six by five inches, and near 340 yards in length."

SECTION XIII.

Mode of Filling.

There is one circumstance in filling the drains attended to particularly by farmers who are most solicitous to have the work well performed, and that is, to contract with their men only for digging and leaving clean, in order that the filling may be done by men paid by the day, as a greater security that it should be executed with all possible care, and is usually attended by the farmer himself, or some confidential servant. This is a rational practice, and merits being followed. Mr. Young, of Clare, observes, in the paper quoted before, that "It is an invariable rule with me never to suffer the man who digs to cover up the drains, but it is left open for me or my bailiff to examine; and then it is well filled up to the shoulder with wheat-stubble, cut and stacked for the purpose immediately after the harvest, and a small stick or two at the outlet, to prevent its being stopped by an external ac-

cident. Lastly, with a common plough I turn a furrow of the upper soil or mould upon the drain, taking care not to turn in any of the dead soil raised by the land-ditch spade, which ought always to be laid on the outside and scattered over the land. It is right not to let the drains lie open any length of time, lest they get injured by wet or frost; my general rule is to fill them up every day."

The different methods of filling both with stone, wood, and straw, will be better understood by examining the Plate.

SECTION XIV.

Of the Expense.

The expense of these drains will, of course, vary with the soil, depth, price of labour, &c.; and these circumstances are so different in different districts, and even in different parishes, that it accounts for the various reports of writers on the subject. The price in Suffolk to dig and fill two spit drains is 3*s.* 4*d.* to 3*s.* 6*d.* a score rods, without beer. In the following notes of Essex draining, other rates are mentioned, and also the cost of materials used in filling, an article liable to equal variations with the labour.

Mr. James Young says,—"It is not easy to ascertain the price of carting the wheat-stubble to the place where it will be wanted, and stacking it, because the value must depend upon the distance; it is equally difficult to say what the work of the ploughs ought to be valued at, for though several acres may be drawn out in a day with one plough, yet I never choose to do above two or three hours' work at a time; therefore I shall leave every farmer to fix his own price upon these parts of the business, only desiring him to consider that it is work that will wait for a leisure time, and frequently, if the horses were not so employed, they would earn nothing.

"I pay for digging the land-drains 1*s.* 8*d.*, and for filling them up with stubble 4*d.* per score rods, without any beer whatever. An active man, used to the work, where the soil is not stony, will dig twenty-three or twenty-four rods in a day, within working hours.

"The state of the expense, that is, the money a farmer

will pay out of his pocket for land-draining an acre of land, will stand thus:—

	£	s	d
For cutting and raking together an acre of wheat-stubble, generally sufficient for an acre of drains	0	2	0
Digging eight score rods of drains	0	13	4
Filling them up with stubble	0	2	8
Extra work with the common spade, on an average, a day's work for a man	0	1	4
	£0	19	4"

Lord Petre says,—"The value of the work of the plough varies to different people's method. My general method is, to plough with a common plough and a pair of horses, two furrows different ways, leaving a baulk in the middle, which I afterwards plough out with a larger plough, and three horses abreast, which will turn a furrow regularly about two inches deeper than the land is generally ploughed. The expense, not reckoning any thing for the master, who, I suppose, attends and marks out the ditches, is about 18*d.* per acre, ditches a rod apart. This method is for fallow. The labour for digging is 2½ *d.* or 2¼ *d.* per rod; and the expense per acre of the whole work is, as near as I can guess, on a fallow where two spits are digged, 43*s.* 6*d.* per acre; with the plough and one spit, about 35*s.*; on lay, with the plough, about 35*s.*; without the plough, and the spits set, about 47*s.* per acre."

Mr. Majendie informs the Board, that the expense to him is,—

Digging the drains with the small or last spit-spade, per score yards, 20*d.* to 24*d.*

Two spits in main drains, 3*s.* to 3*s.* 6*d.*

In this manner the under-draining one acre (the drains at one rod apart), including wood, straw, and all other incidental charges, amounts to an expense of from 40*s.* to 45*s.* an acre.

SECTION XV.

Of Sod, or Pipe Drains.

Various methods have been devised of saving the expense of materials in the filling of drains. The sod, or pipe drains, are undoubtedly the least expensive of any, and may

be of considerable benefit on some soils; but their duration and safety in supporting heavy cattle or horses in the act of ploughing cannot be very much depended on, unless when the opening is at a considerable depth from the surface, and when the upper mould becomes incrusted, or forms an arch.

The method of executing them is by digging a trench of a certain width so deep, and then, by taking out the last spit with the narrow draining-spade, a shoulder is left on each side, upon which a sod or turf, dug in grass-land, is laid, grass-side downwards, and the mould thrown in over it. It is said that such drains will continue hollow, and consequently discharge well for a great number of years. The mode of executing them has been well described, and the tools represented, by T. B. Bayley, Esq. in the valuable "Georgical Essays," published by Dr. Hunter, of York.*

Sod or turf drains are pretty much in use in some of the northern counties of England, where land-stones are scarce.

Several mosses have been drained in Lancashire nearly in the same manner, by leaving shoulders about a foot and a half from the bottom, and laying over these cross pieces of turf or peat cut into lengths of sixteen inches, and eight or nine inches square, which, after they had been dried by exposure to the sun and air, easily support the loose mould that is thrown in above them, the thickness of which being, for the most part, from two to three feet.

How long these drains, in such soft soils, may last good, cannot be ascertained, as it is not long since the practice was first introduced.

Another simple mode of making pipe-drains has been successfully attempted; but it is better calculated for the purpose of an aqueduct, or conveyance for the water, than for drying the soil.

A drain is dug to the necessary depth, narrow at bottom, in which is laid a smooth tree, or cylindrical piece of wood, ten or twelve feet long, six inches diameter at the one end, and five at the other, having a ring fastened in the thickest end. After strewing a little sand upon the upper side of the tree, the clay, or toughest part of the contents of the trench, is first thrown upon it, and then the remainder, which is trod firmly down. By means of the ring, and a

* Octavo edition, p. 437.

rope through it, the tree is drawn out to within a foot or two of the small or hinder end, and the same operation repeated. A gentleman who has tried this experiment, says, "This clay-pipe has conducted a small rill of water a considerable way under ground, for more than twenty years, without any sign of failing."

A simple method to save materials in grass-lands is practised in Buckinghamshire. When the line of drain is marked out, a sod is cut in form of a wedge, the upper or grass side being the narrowest; which is done by sloping the spade in cutting or forming the sides. The sods are taken up in lengths of one foot or eighteen inches, and carefully laid on one side of the drain. After this, the drain is cut to the depth required, by using the draining-spades and scoop already mentioned, which contracts it to a very narrow bottom. The sods are then set in, with the grass side downwards, and pressed as far as they will go, so as to form like key-stones between the sides of the drain. As they cannot go to the bottom, a cavity is left underneath, which serves as a water-course; and the space above is filled to the top with the earth thrown out. If the drain is three feet deep, there will be nearly two feet of earth above the *wedge-sods*, which is sufficient to secure them from any injury by the feet of cattle. This drain is said to succeed admirably, and to last from twelve to twenty years: the expense is one penny per yard.

On sheep-pastures, a very simple mode of carrying off surface-water, by means of a strong common plough, may be effected in this manner:— After turning up furrows through the hollow parts of the field, where the water is apt to stagnate, let a man with a spade pare off the loose soil, leaving the inverted sod or grassy side about three inches thick: this done, let him turn over the sod into the furrow, grass side up. By this, a canal, or opening of three or four inches, will be left in the bottom of the furrow, sufficient to discharge a considerable quantity of water, which will readily subside into it.

A great extent of ground may soon be gone over in this way; and when the furrows choke or grow up, the same operation can be repeated at very little expense. This is peculiarly adapted for sheep-pastures injured by surface-

water; or, in a situation where open *grips* are preferable, the furrow, in place of being *returned*, may be removed to fill up some hollow, or may be added to a dung-hill.

SECTION XVI.

Duration.

The duration of hollow drains will necessarily depend on the nature of the materials with which they are filled, and, in some measure, on the quality of the soil; as certain species of land have the power of preserving wood, or other perishable materials, much longer than others.

Stones last till accidental causes impede the flowing of the water, and may last for ever. Wood perishes in certain periods; but it does not follow that the drains should stop. If the earth arches, the water will necessarily continue to flow; which is found to be the case when wood, straw, and stubble, are rotten and gone. Drains that have been filled with bushes and straw, have been observed to run well forty years after making.

On this subject, Mr. Young, of Clare, observes: "I have never been able to ascertain the duration of the stubble with any degree of exactness, neither have I ever drained a field a second time; but a drain will sometimes be stopped by carting on the land in the wet, or some other accidental cause; in which case, as soon as it is discovered by the wetness of the place, my practice is to make one or more fresh drains, in different directions to the old ones; and I have many times observed old drains, when cut across, though there was not the least appearance of any vegetable substance remaining in them, but full of loose porous earth, at once run freely, or, according to my workmen's phrase, *bleed fresh.*

"During the wet weather, about the middle of last April, I examined a field of six acres, which I land-drained in the month of November in the year 1773, and had the satisfaction to find every drain in the field (except one) running."*—*Annals of Agriculture.*

* Above twenty years.

SECTION XVII.

Drainage of Stiff and Retentive Soils, by Means of Open Cuts, and the Proper Formation of Ridge and Furrow.

It has already been hinted, in Section IV., that on some soils where the surface is very retentive, no number of covered drains can operate effectually in drying the ground.

In most of the central counties of England, and also in Flanders, the general mode of drying land is by ploughing it up in high and broad ridges, from twenty to thirty, and even forty, feet wide, with the centre, or crown, three or four feet higher than the furrows. The successful practice of the Flemings shews clearly how effective this method is when well executed; for, by attentively keeping the furrows perfectly free from water, the land is kept in so dry a state, that all sorts of crops flourish remarkably well: but in England the same observation would not be just, for want of the same attention to this mode of practice. In many instances, the furrows are not properly directed, nor properly deepened, and the ridges too flat; by which the water stagnates in the hollows, and of course renders that part of the field worse than lost. This bad management has brought the method itself into such discredit, that in many places they have been levelling their ridges at considerable expense, in order to adopt some other method of draining; an operation which, on clay soils, is certainly very imprudent; for when the ridges are well rounded, not too high, and the furrows kept open, and perfectly free from retaining water, it must be esteemed, for land of a very retentive surface, an excellent mode of draining, or for keeping it dry.*

Much has been written against high ridges, but not with due consideration of their propriety in such lands: they have been applied on dry loams most absurdly; and from being, perhaps, a custom in that part of the country, no discrimination has been made; but their being improper in

* Water-furrowing is attended with very beneficial consequences when performed in a proper manner, and at those seasons when the land requires it. It is simple; but the omission of it may be attended with the loss of part of a crop; and wetness may often be removed by that means without the aid of drains.

some cases, and ill managed in others, affords no just argument against them, when well adapted to the soil and wetness of climate.*

They prove of great utility, even although united with either open surface, cuts, or hollow drains; as will appear from the following information that has been transmitted to the Board of Agriculture on this subject.

Mr. Francis Goude, of Cossington, in Leicestershire, has united in this manner the ridge method, and hollow drains in the furrows, and with a success that renders his account interesting.

He observes: "That his soil is sandy on the surface, from six to ten inches deep; red clay at the bottom, and in some places gravel, which throws the water upon the surface of the land; which soil we find not easily drained by cross cuts, but requires hollow drains to be made in the furrows of the ridges, which are made from five to ten yards broad. Their height varies; for summer-corn we raise them six inches, but for winter crops, twelve at the crown, above the bottom of the furrows. The hollow drains are thus dug: in turf ground, make the drain fifteen inches wide, and two feet deep, going down sloping: first, take a spade and cut the turf out; then make use of another tool, made on purpose, something like a cheese-taster: at the head, where the man sets his foot, is seven inches wide, going narrower downwards, to the length of sixteen inches, with which he digs out the other materials, whether it be sand, gravel, or clay; if clay, they cut four inches deeper in the middle, at the bottom of the drain, and four inches wide, leaving two inches on each side, or what they call shoulders, to support the turf, which is laid flat upon it, with the grass downwards; then fill it up again: if the land is of a mixed soil, such as sand, gravel, &c. it must be made with thorns, or elm boughs, trampled down, and the turf laid upon them, as before, close to the sides of the drain, so that it makes as it were a wall; but where slab, slate, or stone, can be had, it

* One objection against raising ridges too high is, that the rain falling, washes off more easily the fine particles of the soil from the declivity into the furrows, in which it is carried off the field; and that the seed cannot be so equally disposed in sowing, and must be still more unequally scattered, and drawn into the furrows, by the harrowing: it likewise renders cross-ploughing more difficult.

is still firmer. The bottom of the drain is about four inches wide; and workmen have a tool made the same way as a hoe, or in form of the letter L, with a half-round at the bottom, to scoop out the particles of earth that will remain at the bottom of the drain. How long they will last good is unknown; but I can answer for fifteen years, and expect them to endure a much longer time, even filled with bushes: and the improvement may, upon an average, be estimated at one-fourth increase in the crops."

The mode of ridging and cross-thoroughing (furrowing) land in the Carse of Gowrie, Perthshire, is particularly described in the following valuable communication, by George Paterson, Esq. of Castle-Huntly in that county.

As clay is perfectly impervious to water, surface-draining is the only means by which this species of improvement can be accomplished; and all over the Carse of Cowrie this operation is extremely simple. There are certain large common drains, which pass through the district in different directions, sufficiently capacious to receive the water drained from the fields by the ditches which surround them, and of such a level as to carry it clear off, and to empty their contents into the river Tay: there are also ditches which surround every farm, or pass through them, as their situation may require, but in such manner as to communicate with every field upon the farm. These ditches are made from two to four feet wide at top, and from one and a half to one foot at the bottom; a shape which prevents their sides from falling in; but even then they must be cleansed and scoured every year, at a considerable expense. If the fields be of an uniform level surface, the common furrows between the ridges, provided they be sufficiently deepened at their extremities, will serve to lay the grounds dry; but as it seldom happens that any field is so completely free of inequalities, the last operation, after it is sown and harrowed in, is to draw a furrow with the plough through every hollow in the field, which lie in such a direction that it can be guided through them, so as to make a free communication with any of the ditches which surround the farm, or with any of the furrows between the ridges, which may serve as a conductor to carry the water off to the surrounding ditches. When this tract is once opened with the plough, it is widened, cleared out, and so shaped with the spade, that

it may run no risk of filling up. Its width, from six inches to a foot, according to its depth, which must depend upon the level of the field; but the breadth of a spade at bottom is a good general rule. It frequently happens that there are inequalities in several parts of the same field, which do not extend across it, or which do not pass through it in any direction that a plough can follow, but which may extend over two ridges, or one ridge, or even part of a ridge. Such require an open communication to be made with any furrow which may serve as a conductor to carry off the water, which are always made with the spade. All these open communications are here called *gaas;* and to keep them perfectly clear is a very essential part of every Carse farmer's attention.

It is as yet a general practice in the Carse to have head-ridges, as they are called, at the two extremities of each field; *i. e.* the rising ground upon which the plough turns is laid up in the shape of a transverse ridge, higher in the middle, and falling off at each side; so that a *gaa* is made in the course of the inner furrow, with which the whole furrows between the longitudinal ridges communicate, and into which they pour all their surface-water, which is carried off by similar *gaas,* or openings, cut through the head-ridges at convenient distances, and by which the whole is emptied into the adjoining ditches, and by them into the main drain.

It is supposed that it would be a much better plan, instead of forming head-ridges, as above described, to lay the earth up to the ends of the longitudinal ridges, uniformly, which could be easily done, with a little more trouble, by returning with an empty plough. There would then be no depression between the longitudinal and transverse ridges; of course no occasion for a *gaa;* and by cutting fairly through the head-ridges opposite to every longitudinal furrow, a freer passage would be given to the surface-water, from the whole field to the adjoining ditch, and of course the draining be more complete.*

Besides all this, an experienced Carse farmer will take care that his grounds are carefully ploughed; that the land is laid up equally; that no inequalities are left, so as to hold water; that the ridges are properly rounded, neither too

* This method Mr. Patterson has followed upon all the fields which he has levelled.

high nor too low, but as near as possible to the section of a large circle; by which the surface-water will easily drain off without lodging; and while the crowns are not too much enriched, nor the furrows impoverished, the whole will be made equally fertile, dry, and prolific, and not unfrequently be accessible to the plough earlier in the spring than the fields upon the declivities of the surrounding hills.

SECTION XVIII.

Drainage of Clay Soils injured by Surface-water.

The following method of draining clay soils wet from rain or surface-water, has been practised by Sir Henry Fletcher, Bart. a member of the Board of Agriculture, with great success.

The upper soil, or that above the clay, was from four to ten inches deep, and of good quality; but being in a mountainous part of the country, and near the sea, a great quantity of rain fell, which always kept the upper soil full of water, and produced a very coarse grass, not worth more than 3*s*. an acre. The substratum of clay was of very great depth. The mode he first pursued, and which proved too expensive, was the common one of the country: the drains twenty inches to two feet wide and deep, square, and filled up promiscuously with quarried stones to within nine inches of the surface. The quantity of stones thus requisite was so great, that the quarrying and distant cartage came abundantly too high; so that the total expense did not amount to less than 3½*d*. or 4*d*. per yard, and by the acre to 10*l*. To lessen so heavy an expense, he changed the method to that which he has followed for many years, viz. on grass land he digs twenty two inches or two foot deep; the first spit is of the turf, taken so deep as where it separates from the clay, which is dug carefully out, and preserved unbroken, grass side up, and laid on one side of the cut; then, with a very strong spade, eighteen inches long, six inches wide at top, and two at the bottom, he digs a spit in the clay, which the men spread about the land, on the side of the drain opposite to where the turfs were laid, as far as possible from the drain, so as none may get in again. A scoop, to clear out the fragments in the

bottom, follows, which are also spread in like manner. They are then ready for filling; and in doing this, he takes three stones of a thin flat form, two of which are placed against the sides of the drain, meeting at bottom; and the third caps the other two, as represented by No. 2, in the Plate of Sections: thus a hollow triangular space is left to convey hte water, which is subject to no accidents that can fill it up or impede the current. Stones always sink deeper in the ground; and, in the common method, this frequently causes stoppages, by their being partly buried in the clay; but the triangle, when it subsides, does it regularly, and keeps its form and passage for the water clear. One cart-load of stones, in this way, will do a considerable length of drain. They are carefully laid down by the side of the cut with a shovel, or basket; and if there are any small refuse stones left on the ground after the drain is set, they are thrown in above. The stones being thus fixed, the sods are then trimmed to the shape of the drain, and laid on them, with the grass side downwards, and none of the clay used in filling up.

The expense is a halfpenny per yard, the men earning 2*s.* and 2*s.* 6*d.* per day.*

It is always necessary to survey them twice; first, when the drains are opened, to see if they are of the proper depth; second, when the stones are set, before the sod is laid in.

In regard to the distance necessary from drain to drain, Sir Henry tried them at ten yards; but the spaces in the middle between them were not sufficiently drained. At five yards asunder they were perfectly effective in the most retentive soil; at six, answered well; but he found that they would not operate a cure any where, if more than seven yards asunder. Drains made in this manner give, after many years, no sign of failing, and will probably last for a very long period.

The English acre being four thousand eight hundred and forty square yards, the nearest square of that is seventy yards; and a square of seventy yards, drained at seven yards' dis-

* A man, his wife, and a child of ten years old, with a horse and little cart, made very good wages of it: the man used to cut the drains in open weather in winter; in frost he wrought in the quarry; his wife filled the stones and led them to the drains, laying them down along the sides at proper distances, and the child set them in the triangle at bottom.

tant, is ten drains of seventy yards each; consequently there is seven hundred yards of drain in an acre, or one hundred roods, of seven yards each, which, at a halfpenny a yard, is 1*l.* 9*s.* 2*d.* per acre.

When this is the price, the stones are not more than half a mile distant; if farther off, allowance must be made for the extra cartage; or, when the ground turns out stony, hard, and ill to dig, a farther allowance is likewise made.

SECTION XIX.

Of Open Drains.

As there are many situations where open drains only can prove effectual, for a description of these I have added this Section.

It would be unnecessary to give any particular directions for their depth or wideness, as that must depend on the quantity of water they are to receive or convey, and on the nature of the soil, and situation in which they are to be made. One rule, however, may be general, — that the width at bottom should be one-third of that at top, which gives a sufficient slope to the sides, and prevents their falling in; and the fall or declivity should be such as that the water may run off without stagnation, but not with too rapid a motion. The first is necessary to carry off any sludge and grass, &c. which may get into them; but if the descent is too great, the water will be apt to form inequalities in the bottom, and wear down the sides. In moss, and in very soft soils, a greater degree of slope may be necessary; and in all cases where it is meant for a drain only (*i. e.* to receive surface-water), none of the earth thrown out should remain upon the sides, but should be carried to, and spread in, the nearest hollows. When this is not done their use, in a great measure, is counteracted. The earth, when left upon the sides, prevents the surface-water from getting into the drain; its weight causes the sides to fall in, makes it more difficult to scour or clean it, and adds much to its disagreeable appearance in the middle of a field. In soft marshy ground, when it may be proper to have the line of drain *a fence*, a smaller parallel cut, will be necessary along the back of the bank or

earth thrown out, to receive the water from that side, and by which it may be conveyed to a proper place for its admission into the ditch or larger cut.

When it may be necessary *to bore* in an open drain, the manner of doing it has been explained in Chap. V.

In all cases where the admission of surface-water, or what may be augmented in time of great rains, is unavoidable, the drain must necessarily be open to prevent the risk of choking or filling up, which is always the consequence when such water is admitted into a covered drain. This, in the middle or hollow part of a field, may not only be hurtful to the eye, but a considerable obstruction in the act of ploughing. It may, however, be remedied by giving the drain such a slope as it shall grow green on the sides, and the plough or cart may pass over it without interruption; and the line of direction should be, if possible, parallel to that of the ridges, so as to give less obstruction to the cultivation of the field. When the field is in pasture it can have no bad effect whatever, as cattle pass over it with ease; and being covered with grass to the bottom, no ground is lost. If there be a constant run of water in it, independent of what is collected from the ground on both sides in wet seasons, that may be confined to a narrow channel cut a little deeper in the middle. However great the slope, it should not be ploughed with the rest of the field, but should always remain green, as a sudden or great run of water passing through it, when loosened by ploughing, would wash down the sides and destroy its shape. In young plantations open drains are the only kind applicable, as the roots of the trees getting among the stones, and leaves choking their outlet, would soon render covered drains of very little use. In lawns, and among thin grown-up wood, covered drains may be proper for cutting and carrying off springs, and may not be so liable to any defect from the interruption of roots or accumulation of leaves, and will not appear unpleasing to the eye. Very small and narrow open cuts (commonly called *grips*) are very useful in the wet hollows of smooth pastures, to receive and carry off the stagnant water, and part of the rain as it falls. These are commonly one foot deep, eight inches wide at top, and the sides contracted so as to meet at bottom. The only objection to them is, their being easily

stopped by the feet of cattle trampling upon them; but it requires very little time and trouble to keep them clear.

Sunk fences, also, come under the denomination of open drains; but the nature and construction of these are so generally known, and must vary according to situation, that no description of them is necessary here.

All open drains require to be scoured out and cleaned at least once a-year; for when this is neglected, they loose their good effect, and the operation becomes the more difficult afterwards. Although they cost less at first, this annual repair renders them more expensive than covered drains that are not exposed to any outward obstruction.

SECTION XX.

Of the Benefit derived from Draining in general.

In the Introduction, I have mentioned some of the advantages that arise from a proper drainage of land; and, also, what further benefit may be derived from the principles of Mr. Elkington's system being applied to other useful purposes. Here I shall only add a few observations communicated to the Board on this subject, as the advantages, in general, are so obvious to every one.

Of all the improvements by which intelligent husbandry has advanced the value of land to the equal benefit of the owner, occupier, and to the public, there is not, perhaps, another from which so many advantages have been derived at so moderate an expense.

Soils that are wet from spring or from rain-water are equally unproductive till laid dry. Seasons of tillage are lost if the land is in an arable state,* and, in very wet years, its produce is scanty and precarious; but when *well drained*, all other exertions of good husbandry are attended

* That the ancient Romans were sensible of this, and that wet land was fit neither for being ploughed, harrowed, nor planted, Columella observes.—"Ne lutosus ager tractetur . . . Nam quæ limosa versantur arva toto anno desinunt posse tractari, nec sunt habilia sementi, aut occasioni aut stationi."—Col. lib. ii. cap. 4.

with beneficial consequences, and take full effect: the farmer thrives on the same farm on which his predecessor was ruined! Of its effects on grass-land, Lord Petre observes, that "the land, after draining, not being so much chilled by the long continuance of the winter-water on the surface, produces earlier vegetation in the spring; the grass is rendered of a better kind; the white clover is encouraged, which seldom fails in Essex and in Hertfordshire to chequer the *land-ditched* fields with its sweet appearance."* And again:—"Tillage-land is much more manageable; it dries gradually, and early in the spring; the bad effects of land being catched full of water when the parching winds in March suddenly harden the surface of wet grounds is prevented, and the earth breaks kindly. This, in a short time, alters the very nature of the soil; the weeds and grasses change their colour; every plant that grows loses the appearance of rankness; the corn increases in quantity and weight; and every benefit a farmer can wish is more or less the consequence of this first of all improvements, in proportion as the soil draws well or ill."

Respecting the farther advantages of the practice on arable land, he likewise observes:—"The great advantage of land-draining is, we can plough earlier in the spring, and later in the autumn, and it certainly makes the land tilth easier; and the land can be kept clean with less expense; but it is too much for the farmer to expect his return the first crop. I believe I have known some particular piece that has repaid the expense in two crops. It certainly is a very beneficial improvement to the farmer."

Mr. Young, of Clare, says:—"I have a field that used to be so wet and poachy in the winter as not to be able to bear the weight of a sheep; I land-drained and fallowed it, then sowed it with wheat, without any manure, and had a crop equal to half the value of the land."

In speaking of the improvements in the county of Essex, Mr. Vancouver has the following remark on the importance of draining:—"There is no improvement to which the heavy-land husbandry of this county owes so much, as to the fortunate introduction and continuance of the practice of hollow-

* Annals of Agriculture.

draining. The means of melioration, and the consequent sources of fertility thence derived from the soil, over and above what it formerly yielded, are not more important and valuable in the present day, than permanent and precious, as they must prove, in their consequences hereafter. The few instances of invincible blindness to the beneficial effects of this excellent practice go no farther than to prove, that where the work is not improperly executed it never ceases to fail in producing the desired effect."

APPENDIX,

CONTAINING

HINTS FOR THE IMPROVEMENT OF BOGS, &c.,

AFTER BEING DRAINED.

APPENDIX.

HINTS FOR THE IMPROVEMENT OF BOGS AFTER BEING DRAINED.

The next thing to be considered, after a bog or piece of marshy ground has been completely drained, is the means most easily accomplished and best adapted for its further improvement. If the bog is overrun with rushes and other coarse aquatics, nothing will tend sooner to the first part of its improvement than *over-stocking* it with cattle, so soon as it acquires a sufficient solidity to bear them with safety; but care must be taken not to put the cattle on it until it is sufficiently firm, otherwise the surface will be poached, and the coarse herbage not closely bitten: thus will the coarse grasses be closely ate down, and the pressure of the cattle will help to consolidate the surface. By this alone, it is wonderful to see the difference of verdure that soon takes place; and it is worthy of remark, that a bog of the worst kind, after being drained and so treated, without any other melioration whatever, should spontaneously produce so many fine grasses, that have hitherto lain dormant, and by the superfluous moisture been prevented from coming forth, should, as it were, all at once be called into existence, and afterwards continue to flourish and increase. The rushes will soon decline, and give way to better grass, which will spring up in abundance. Lime or marl, spread on the surface, will greatly increase the growth of white clover, and other kinds of fine natural herbage, after the rushes and coarse plants have been closely cut and ate down with the cattle.* The first thing, however, to be done, whether the field is to remain in the natural state of pasture, or to be cultivated by tillage, is to level the surface; the natural irregularity of which is, in most cases, an obstruction that ought first to be removed. The earth that composes the highest parts should be removed, and mixed into a compound with lime, to be used either as a manure

* The best time to cut rushes, &c., is when the shoots are weak, and before the seed comes to maturity. If left till the seed is ripe, it shakes, and, falling on the ground, multiplies their growth. They should be *frequently* cut before this season, which will soon extirpate them.

for a crop, or spread on the surface as a *top-dressing* for grass. Earth of inferior quality may be substituted for filling up the deepest hollows. Where the nature and situation answers, no improvement is so cheap, so sure, or so profitable, as converting a certain class of bogs into water-meadow.*

If it lies along the side of a river or stream, of which, by means of proper dams and cuts, a command can be obtained; and if the process of irrigation is managed with skill and attention, it never fails to produce luxuriant crops of grass. This crop is in every respect best adapted to the nature of such ground, being less affected by the inclemency of a cold or moist climate, and giving a more sure return, without the labour and expense of annual culture, than any crop of grain that might be produced. As a proof of this, I shall only mention the water-meadow on the estate of Odstone-Hall, in Leicestershire, which, from being mere bogs, before being drained by Mr. Elkington, now produces as abundant crops of grass as any of the kind (water-meadows) in that part of the kingdom. As a farther instance of the good effects produced by watering this kind of land, Mr. Boswell, in his treatise on that subject, says:—"Lands that are very boggy require more and longer watering than any sand or gravelly soil. The larger the body of water that can be brought upon them the better: its weight and strength will greatly assist in compressing the soil, and destroying the roots of the weeds that grow upon it; neither can the water be kept too long upon it, particularly in the winter season, immediately after the *after-meat* is eaten; *and the closer it is fed the better.* This species of soil, after being *well drained* and watered, will equal the wishes of the most sanguine by its improvement."

No general system of irrigation can be properly laid down applicable to every particular case, farther than some general directions, that hold good in every situation; but, in other parts of the process, different modes must be adopted,

* It must be understood, that the surface of the bog has been properly levelled, well rolled, and a good sward of grass on it, before the operation of floating can be attempted. It is a fact well ascertained, that in Merionethshire there is land that was formerly not worth 6*d.* per acre; but being now *drained and flooded*, besides affording excellent pasture till the 1st of June, produces two tons of good hay, cut in the beginning of August.—*Agricultural Report of Merionethshire.*

according as the situation and form of surface require. In those where the command of a river or stream can be obtained, the general rule is, to collect a sufficient quantity of water, nearly on a level, in a main carier, which can, by means of sluices constructed at proper places in the sides of it, be let out into floating trenches, cut along the surface of the field, or sides of the declivity, one below another. These floating trenches will collect the water from above, after passing over the spaces of ground betwixt each, and distribute it equally over the surface of each space lying between them, alternately. Proper attention must be paid, at the proper seasons, to open and close the sluices, in regular rotation, so as to flood different portions of the land successively; and the floating gutters should frequently be cleaned and scoured out to prevent their choking up, and to destroy the growth of rushes, or other grass that may grow up in them. From the very absorbent quality of the peat, the water would require to have a more rapid motion on bogs than on soils less porous or spongy. The saving of manure is another circumstance in favour of water-meadows, as the application of it would appear to be of no material consequence, being very seldom used by some of the best flooders in England.* Still, however, I should think, that the use of lime or *shell*-marl, diluted in the water of the upper carier, would be attended with the most beneficial effects. Its finer particles would thus be intimately diffused over the surface—would be lodged in closer contact

* The late celebrated Bakewell, who was a great advocate for watering, used no manure on his water-meadows. It was a favourite idea of his, that water made to float over the greatest bog or swamp, *without being drained*, would not only have the effect of producing a finer herbage on it, but that the pressure of water artificially brought upon it, would force back that with which it was already overcharged, into the channel from which it sprung. Nothing can be more absurd, and which the following fact will prove: At Drayton Park, near Tamworth, in Staffordshire, a considerable extent of bog was thus watered, by a cut for that purpose, conducted under the direction of Mr. Bakewell, at a very great expense, and which, after being completed, had the effect of rendering the ground much worse, and more swampy than before. This, to the surprise of Mr. Bakewell (but not entirely to his conviction), not having the effect which he argued it would, Mr. Elkington was applied to, who, by means of a drain which he made, and which did not exceed *one-third* of the expense of Mr. Bakewell's water-works, has rendered the ground worth *ten times* its former value, and which now produces crops of grain equal in value to any that is produced in that country. This is mentioned as a proof that land of that description, without being previously drained, can never be watered with advantage.

with the roots of the grass, and afford them additional nourishment to what they receive from the fertilising qualities of the water. The operation would be simple, and the expense trifling, from the small quantity of lime sufficient for the purpose. The lime should be laid down along the side of the uppermost trench or carier, and, after being *slacked*, put, in small quantities, among the water in the cut, and, being stirred about, would be carried down by the stream, and equally diffused over the surface. It is to be observed, that the lime, or shell-marl, is only to be used in this manner the last days of the watering. If there was not so heavy a duty upon it, the refuse of salt, used in this manner, would be a valuable improvement, its fertilising qualities being equally beneficial on pasture as well as on arable land.* These experiments I have never seen practised, although recommended; but it is obvious to every one who is in the least acquainted with the manner of flooding, and with the qualities of these manures, that it must prove beneficial beyond a doubt.†

As it is only in certain situations, where this mode of improvement, by means of water, can be adopted and prac-

* In a communication to the Board of Agriculture, on the nature and qualities of salt, as a manure, by Mr. Roalfe, of Sandwich, he says:—"Salt is also excellent upon rushy and sour pastures, which are subject to occasion the rot in sheep; such is its effect, that it prevents that destructive evil from attacking them."

† A method nearly similar to this seems to be practised in watering ground in Switzerland, as appears from the following remark in a treatise, entitled, "Le Socrate Rustique," 1764:—"Our cultivator considerably augments the vegetative properties of the water by *rich mould*, procured, as I have already mentioned, from green turf, cut from eminences in pasture or fallow land. This he throws into the principal head of water, so that the lesser channels may imbibe and communicate fertility over the meadow." In a note by the translator, alluding to this passage, he says:—"This is a good thought; but the benefit on some soils, of casting *slacked lime* into the stream, would be much greater, and acquired at a much less expense."

Another method, practised by Mr. Miller, of Dunstall, in Staffordshire, merits attention: on the stream which he applies to the floating of his ground, are two ponds, for the purpose of supplying mills situated below. From these ponds the floating trenches are supplied; and as there is always a quantity of fine mud deposited in the bottom of them, this he stirs about, so as to be carried along with the water, and equally distributed over the surface. The success of this practice warrants its recommendation.

Although the watering of land is now arrived at a very great degree of perfection, yet these hints seem to have escaped the attention of most practical flooders.

tised with advantage, I shall next take notice of the other means that may be used, and that are best calculated for the improvement of bogs, by converting them into a state of cultivation so soon after draining as they become accessible to the spade or the plough.

If the bog is of considerable extent, the first thing to be done after draining, or which may be done at the same time, is dividing it into proper inclosures, by open ditches.

These will assist in carrying off the surface-water, which the covered drains do not effect; and part of the earth thrown out of them may be mixed in a compound with dung and lime, or made use of in filling up some adjacent hollows. If the ground is to be pared and burnt, part of it may be burnt along with the turf; but this is supposing that no thorns or quick-fence is planted along the ditches; in which case, no bank of earth is requisite on either side. In ploughing, regard must be paid to the proper direction and inclination of the ridges and furrows towards the open ditches, in order to discharge the rain-water as it falls.* The great object is, to get the ground brought to such a state as to be fit for being laid down with grass-seeds, when it may be considered in such a state of improvement, that any subsequent crops will require no more than ordinary management to cultivate.

In levelling or smoothing the surface, it will be necessary to use the spade, by which the work will be done nearly as expeditiously, and much more effectually, than with the plough at first. There are various opinions, how far paring and burning is conducive to the improvement of land. Some have condemned it, as a practice that ought to be exploded

* Some bogs, when *too much drained*, are apt to become parched in dry seasons. To remedy this, if the ground is very flat, or nearly level, sluices may be made in the lower end of the division-ditches, which, in very dry seasons, may be let down, to keep in the water received from the top drains. If the ditches have a descent, so that the water cannot stand level all the way, several sluices of this kind will be necessary, or the water may be stopped, by building in turfs. The water may be allowed to stand within a foot, or a foot and a half, of the surface, and, by its stagnation, will ooze through the peat, or upper soil, and afford such a degree of moisture as will greatly relieve the crop. If in pasture, the cattle should not be allowed to feed on it while the water remains in the ditches, nor for some days after, as they would *poach* the surface too much; and the heat would make them go into the ditches, where they might not easily get out.

on every soil; yet on a certain class of boggy ground, it may be considered as a very great improvement, not only from the excellent manure that the ashes produce, but also from its destroying the roots of every noxious plant more effectually than could be done by means of fallowing alone. The ashes of the burnt turf, when mixed with the soil by a superficial ploughing, so enrich it as to produce excellent crops, for two years at least; and if a little lime is added, it will help sooner to pulverise and heat the soil. If the bog is covered with long heath, or ling, and other coarse *benty grass*, it might be proper to burn it *growing*, without paring off any part of the soil; but this would yield only a small quantity of ashes, neither would it destroy entirely the roots of the plants, and, when ploughed in, would produce very little effect. So soon as the turfs are reduced to ashes,* they should be equally spread over the surface, ploughed in with a light furrow, and turnip or potatoes ought to be the first crop. If the former, they should be sown *broad-cast*, and fed off with sheep. By this, the soil will receive great benefit from the dung and urine, the refuse of the plants, and by being consolidated by the trampling of the sheep. It will then be in good state for a crop of oats or barley, which should be sown with grass-seeds, well rolled down. The ploughing, after the turnips are ate off, should be very slight, not to bury the sheep's dung, &c. too deep; in which case, a crop of oats is preferable to barley, as the preparation of the ground requires less ploughing. If the soil is full of the roots of rushes, and other weeds, a course of summer fallow will be requisite, before any crop is taken; and if the ashes have been made in one corner of the field, they can be spread over the surface, before the seed-furrow is given; and the roots and tough clods may be collected into heaps, burnt, and spread along with them.

If the bog is deep of peat, and very soft, so as not to be

* In burning the turfs, after they have been properly dried, they should be set up in *large heaps*, adding to them as they burn. This confines the smoke and flame, by which so much of the essence is evaporated and lost, when the turfs are burnt in small heaps.

Paring and burning the turf is, in some places, begun in the month of March; but it is better to delay the burning till April or May. The paring, however, may be done in March, and the turfs will be dry enough for burning in the month following.

fit to carry horses for ploughing it the first year, a crop of *turnip broad-cast* may be got, by sowing the seed among the spread ashes, harrowing it in with a light harrow and roller, drawn by men. The turnip should be ate off with sheep, and the ground will next year be so much consolidated as to admit the plough.

If the surface is not pared and burnt at all, a course of fallow, even for two years, will be necessary to reduce the soil to a proper mould; in the last stage of which, the lime, or other manure, may be applied. In this case, two white crops, with an intervening one of turnip, potatoes, &c., may be taken, before the grass-seeds are sown.* All boggy soil whatever, after being once broke up and pulverised by tillage, and a course of summer fallow, should not be over-cropped before being laid in grass; and when once brought into a good *sward* of grass, should not be too soon broke up, but continue so, brush-harrowing and top-dressing it, when the herbage begins to fog: frequent rolling is also very necessary on such soft soils.

It is better to feed sheep the first and second years of the grass than to cut it for hay, as it causes the roots of the plants to strike more horizontally through the soil, and more closely

* Rye, being a hardy grain, and thriving on very poor soils, is a very profitable crop on *drained boggy land, pared and burnt*, as appears from the following extract of a communication to the Board of Agriculture, respecting the state of husbandry in the neighbourhood of Petersburg:—"Rye-bread, as every body knows, is the chief support of this district, as well as of the other northern parts of Russia; but, in order to save the rye-flour, and to make it last the longer, the inhabitants, when compelled by necessity, mix with it *fine-ground oatmeal*, the meal of buck-wheat, and the husks of the field-mustard seed (*sinapis arvensis*). The produce of rye in very few places varies more than here. The poor sandy lands will hardly produce more than three times the quantity sown. The middling sorts of land produce four and six times the seed. The rich and well-manured lands, and such where wood has been cleared off, will produce, in a good season, ten or twelve for one sown: but the most extraordinary produced is gathered from *boggy lands, drained*, and sown with rye; as in a favourable season it increases forty times, and upwards. The reason of this extraordinary increase must be explained: it is owing to the ashes produced *by burning the bogs*, which assist the vegetation to that degree, that frequently they find one grain produce forty plants, and even more: for this reason they generally use a much smaller quantity of seed in sowing such land. There is no need to sow clump rye (*secale multicaule*) upon such lands, as any good common seed increases very much upon so rich a soil, to which the burning of the surface has added so much of the vegetative power. The seed is sown in July or August, and is reaped about twelve months after."

cover the surface. For this purpose, a greater proportion of white and yellow clover, and other *short grass*-seeds, should be sown. In the second breaking up of the ground, after lying some years in pasture, no particular mode of practice, or rotation of cropping, can be laid down: the state of the ground, then, must be the rule for after-management, and by which time it will not only have attained a firmer texture, but also a degree of strength, to produce any crops, with proper manure and cultivation. In manuring soft boggy soils one precaution is necessary. The deeper the ploughings are, previous to the dung being laid on, the better; but the subsequent furrows should be very superficial, and the dung intimately mixed: for when it is ploughed in too deep, not equally distributed and incorporated with the soil, it is apt to subside below reach of the plough or horizontal roots of the grain. The same is the case with lime, which always penetrates deeper into the soil; and marl, when buried too deep, loses all its effect.*

Upon soft boggy land, intended only for pasture, nothing will work a more quick improvement than covering it with a thin stratum of clay, gravel, or any other earth heavier than that of which the bog is composed. Clay-marl, where it can be got, is, of all others, to be preferred, both on account of its greater weight and enriching qualities. Sea-sand, being mixed with shells, is peculiarly adapted for this purpose, if the bog is situated near the sea where such can be easily got. The weight and pressure of these heavier bodies makes the bog soon become more solid, and likewise presses out more quickly the moisture contained in the spongy peat; the thicker, therefore, it is laid on the better. A thin sprinkling of lime over it will add to its effect, and cause white clover, and other sweet grasses, to spring up in greater abundance. The most barren soil will have a good effect when used in this manner; but, of all others, lime-stone gravel is preferable. By means of it many extensive bogs are improved in Ireland, where it abounds; but very little of it is found either in England or Scotland, which renders that mode of improvement impracticable. After the ground has been thus treated,

* Coal-ashes is an excellent manure for sour wet land, either used as a top-dressing for grass, or, if ploughed in, tends greatly to destroy the tenacity of stiff soils, and render them more productive.

and lain some years in pasture, it may be broke up by tillage, and crops of grain taken, before being laid down with *grass-seeds*. By ploughing it, part of the natural soil will be turned up, and intimately mixed with the earth, &c., that has been laid upon it; and, if lime or dung is added, will altogether form a very fertile mould.

Such are the methods by which many bogs have been cultivated and improved after draining, in several parts of England; the success of which is a sufficient recommendation of the practice. But *these hints* are not to be considered as the only means whereby this improvement can be effected: there are others equally beneficial, and in many situations equally applicable; by means of which, there is no doubt that much *boggy ground*, however barren in its natural state, may soon be rendered highly productive. But to enumerate these would be unnecessary; for every one who possesses ground of this description will be able to ascertain what mode of management is best calculated for its situation, what crops he wishes to raise, or what kinds of manure he has in his power to apply.

As no method yet practised for the improvement of moss has equalled, in produce and profit, that so successfully introduced by Mr. Smith, of Swinridge-Muir, in Ayrshire, a short account of the process, and result therefrom, may not be unacceptable to many readers.*

The moss is of two different kinds; the black, and the red, or flow-moss: both are of a considerable depth, from four to twelve feet; but the first is reckoned more valuable, in several respects, than the other.

The first thing is, to mark out and cut proper drains (taking advantage of the declivity) to draw off the superfluous water, and to divide the moss into separate small inclosures. These drains, or ditches, are commonly eight feet wide at top, two feet at bottom, and four and a half feet deep, when first cut; but as the moss afterwards subsides, they become less: they cost 2*d.* per lineal yard. After these have been cut, and the moss thrown out has been spread from the

* The author visited Swinridge-Muir when the moss was preparing for crop, 1798; and this account of the process is partly from his own observation, and from a very minute account of it, published in "A Letter to a Friend," in 1796.

sides, and the hollows filled up, the ridges are marked off parallel to the sides of the inclosure, twenty feet in breadth. They are formed by leaving a space of twenty inches untouched in the middle of the ridge, and turning up on each side of this a furrow with the spade, which is laid over the untouched space, so as to raise it to a proper height above the sides. The whole breadth is then dug by turning over with the spade furrows a foot in width, which has the appearance as if done by the plough. The division-furrows are small drains about two feet deep, and as wide, for drawing off the superfluous moisture, and conveying it into the main drains. The ridges must not be formed too high and too narrow, nor the furrow-drains cut too deep, otherwise the moss will be left too dry, and consequently prevent the action of the lime, which requires a certain degree of moisture to have a proper effect.* The next thing is *top-dressing* the ridges with *new slacked, or powdered lime*, at the rate of 500 Winchester bushels per acre; *i.e.* 250 bushels of shell-lime.† The moss is prepared for the first crop early in the summer preceding; in which time the lime, aided by the effects of the different seasons, has so far meliorated the soil for reception of the seed.

Potatoes planted in the *lazy-bed* way ought always to be the first crop, when dung can be got.‡ The potato-beds are formed across the ridges. A thin layer of dung is then spread over the beds, and the cuttings laid about a foot asunder, and covered (to the depth of a few inches) with the mould taken out of the trenches between the beds. When the plants appear above ground, they get another thin covering, by a second scouring of the trenches; and they require no hoeing till they are taken up. The produce is never less than forty or fifty bolls, of eight Winchester bushels, and the quality excellent. When the potato crop is removed, the ridges are again formed in the manner as before, and the division-furrows cleared out.

In this state the ground remains till next spring, when

* In very dry weather this may be remedied by stopping the lower end of the drains and retaining the water; and if there is a command of any spring or higher water, it may be let into the main ditches: but too much moisture is likewise to be guarded against.

† Scotch; equal to one acre and one-fourth, English.

‡ The quantity of dung is about eighteen or twenty single-horse cart-loads to an acre.

oats are sown and harrowed in with a small harrow drawn by men. The early oat is always preferred for seed, the late seed running too much to straw. The produce of the first two crops of oats is seldom less than ten bolls (of six Winchester bushels) per acre, and that of the succeeding crops six or eight bolls, and often more. Five or six successive crops of oats are often taken without receiving any additional manure, or exhausting the strength of the moss. By this time its nature has undergone a considerable change, and has now the appearance of a rich black mould, and is sown down with grass-seeds. It is not so favourable to the growth of barley, which is never sown before the first grass. When no dung can be had the first year, and oats taken with lime alone, the crop often misgives; which is a proof that *without dung and potatoes for the first crop*, it cannot be productive. The different kinds of marl are well adapted, and may sometimes serve as a substitute for lime; but dung is an inseparable appendage. After the process thus described has been gone through, and the moss lain a few years in grass, it can be ploughed safely with horses; which lessens the annual expense of labour without diminishing the produce. The spade is the only implement for the first years; and it is astonishing with what neatness and expedition the accustomed workmen perform the operation. It is sometimes ploughed the fourth year, where the moss is not very deep.

When laid down with grass-seeds, the hay crop is often abundant, and the pasture, afterwards, worth 1*l.* 5*s.* per acre; which shews that the preceding oat crops have not exhausted too much of its strength.* Rushes are very apt to grow up in the pasture; and the *poaching* of heavy cattle ought carefully to be avoided in wet seasons.

Abstract of the Annual Expense and Profit per Acre, for five Years.

	Crops.	Expense.	Profit.
1st year,	Potatoes,	£15 18 5	£ 0 11 7
2d ——	Oats,	3 2 0	4 3 0
3d ——	——	3 11 4	3 13 8
4th ——	——	3 5 2	1 0 10
5th ——	Hay,	0 12 0	3 4 8
		£26 8 11	£12 13 9

* By this it does not seem so necessary to lay down with grass, after once manuring it, as in dry land; for the crops fail little in produce; and the great desideratum is, to have plenty of straw for producing dung, so invariably requisite for the first crop. An intervening crop of turnips would be an improvement in the rotation.

Average profit 2*l.* 10*s.* 9*d.* per annum, and will let for 1*l.* 5*s.* per acre, in pasture.*

The different articles of expenditure making up this abstract are stated at the highest rate, and the articles of produce equally low; so that, on the whole, it may be reckoned a fair average: but the distance from lime, in many places (which is here at hand), must alter the calculation and increase the expense.

A great deal of moss has now been improved, by cultivating it in the same manner, in the counties of Ayr, Renfrew, and West-Lothian; and, indeed, these examples have been the means of inciting others to follow the same practice in different parts of Scotland, and which is every day becoming more general.

CONCLUSION.

I HAVE thus endeavoured to explain, in as precise and explicit a manner as the nature of the subject would permit, the various circumstances and data on which the art of draining land is founded, together with the manner of its application in different cases, and such directions as I hope will enable the practical farmer to profit by the discovery.

It will afford me the most lasting satisfaction if this work is found materially to contribute in extending the knowledge and practice of an art of such general importance, and so likely to promote the interest of the farmer and of the public in general.

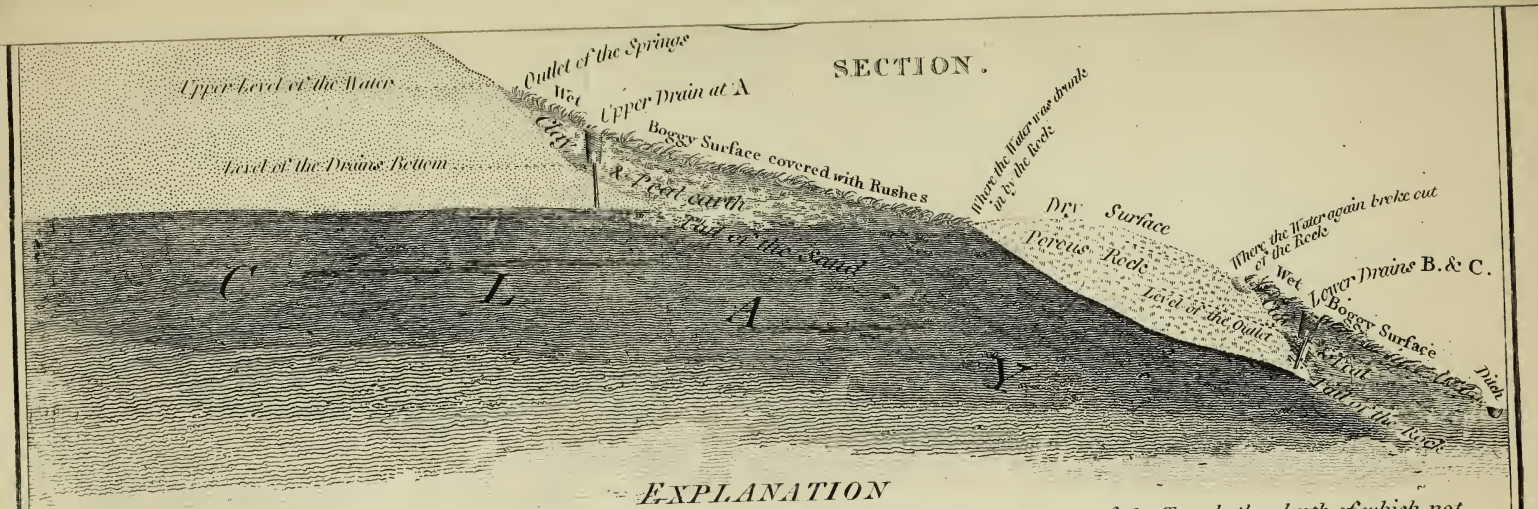
JOHN JOHNSTONE.

Edinburgh.

* For a detailed account of the expenditure and profit the reader is referred to the Letter already mentioned, from which this extract is made up.

THE END.

LONDON:
PRINTED BY MOYES AND BARCLAY, CASTLE STREET, LEICESTER SQUARE.

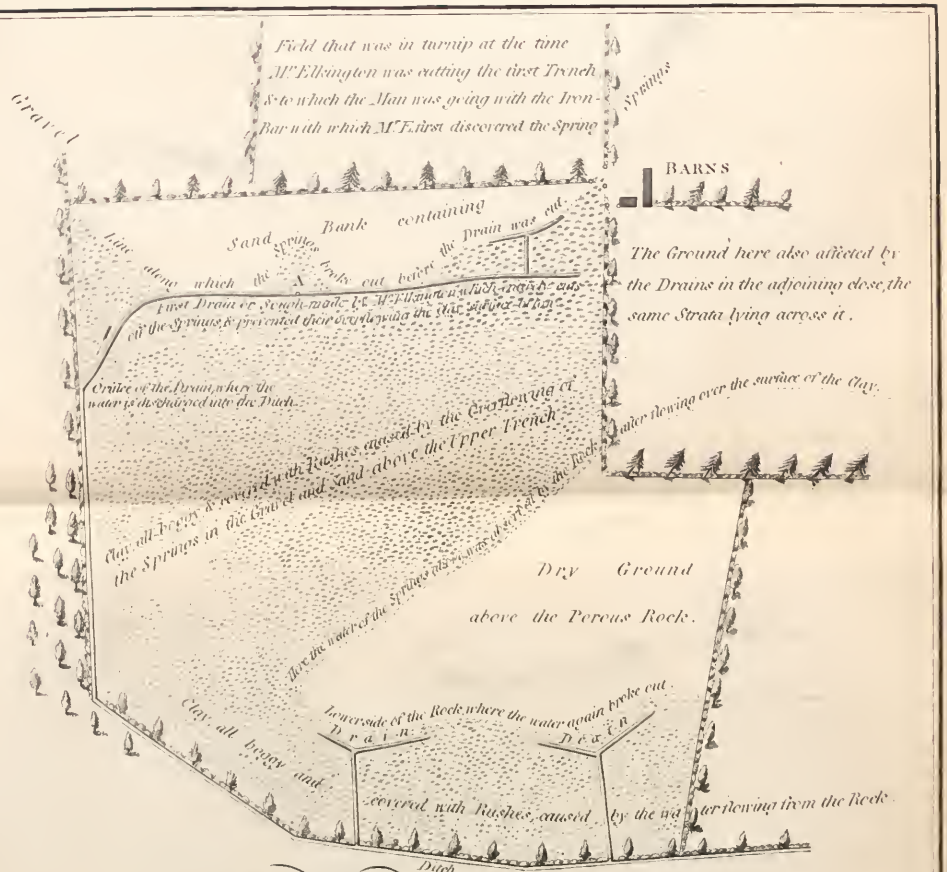


EXPLANATION

A. in the Plan, represents the place where the Clay pointed up on the surface above the line, and below the bottom of the Trench, the depth of which not reaching the Spring, induced Mr. Elkington to push down the Iron Bar, which at 4 feet below the bottom of the Drain, caused the Water to burst up, and thus was the first means that led him to think of applying the Auger as a more proper Instrument in such cases, where the depth of the Drain does not reach that of the Spring, and upon this all his future practise has been grounded.

Jn.o Johnston del.t

Neele sculp.t 352 Strand.

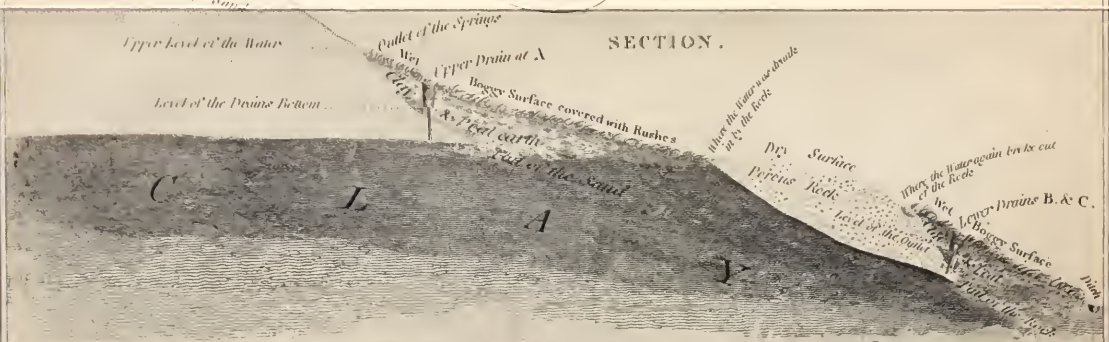

Field that was in turnip at the time
Mr Elkington was cutting the first Trench
& to which the Man was going with the Iron
Bar with which Mr E. first discovered the Spring
Springs
Gravel
BARNS
Sand
Spring
Bank containing
the Drain was cut
Little
along which the
A
broke out before
The Ground here also affected by
the Drains in the adjoining close, the
same Strata lying across it.
First Drain or Scrogh made by Mr Elkington which stops the out
cut the Springs & prevented their overflowing the Clay above it.
Orifice of the Drain where the
water is discharged into the Ditch
Water flowing over the surface of the Clay.
Clay all boggy & covered with Rushes caused by the Springs in the Gravel and Sand above the Upper Trench
Dry Ground
above the Porous Rock.
Here the water of the Springs rises in many places out of the Rock
Lower side of the Rock where the water again broke out.
D r a i n.
D & C
Clay all boggy and
covered with Rushes caused by the water flowing from the Rock
Ditch

Plan of
LONG HAROL PITS,

Part of the Farm of Prince Thorp in Warwickshire,

Being the FIELD in which Mr ELKINGTON first discovered his MODE of DRAINING,

An. 1764.

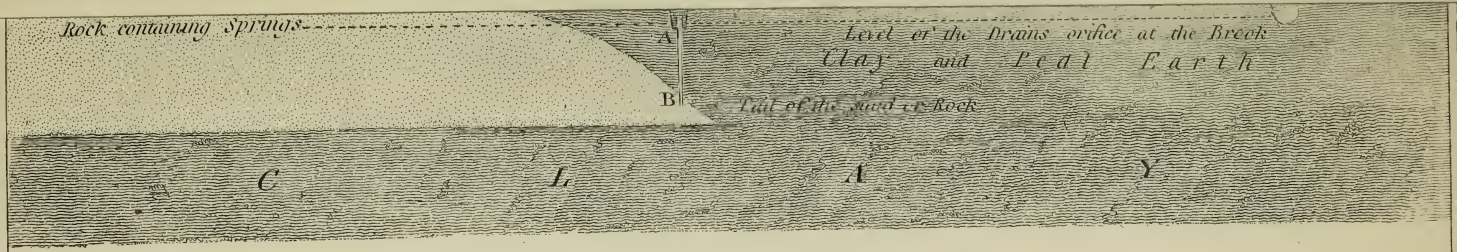


EXPLANATION

A. in the Plan expresses the place where the Clay printed up on the surface above the line, and below the bottom of the Trench, the depth of which not reaching the Spring, induced Mr Elkington to push down the Iron Bar which at 4 feet below the bottom of the Drain caused the Water to burst up, and this was the first means that led him to think of applying the Auger as a more proper Instrument in such cases where the depth of the Drain does not reach that of the Spring and upon this all his future practice has been grounded.

Jas. Johnston del.

Neele sculp. 352 Strand.



If the stratum of Clay where the Trench is cut, be thicker than the Level of the Orifice will admit the Depth of the Drain to be, (A. representing the Depth of it at that Level,) the remaining part of that Clay from A. to B. must be perforated by the Auger to the Tail or lowest point of the Sand or Rock at B, when the Spring will immediately rise up into the Trench by the pressure of its waters above the Drain's Level.

J. Johnston del.

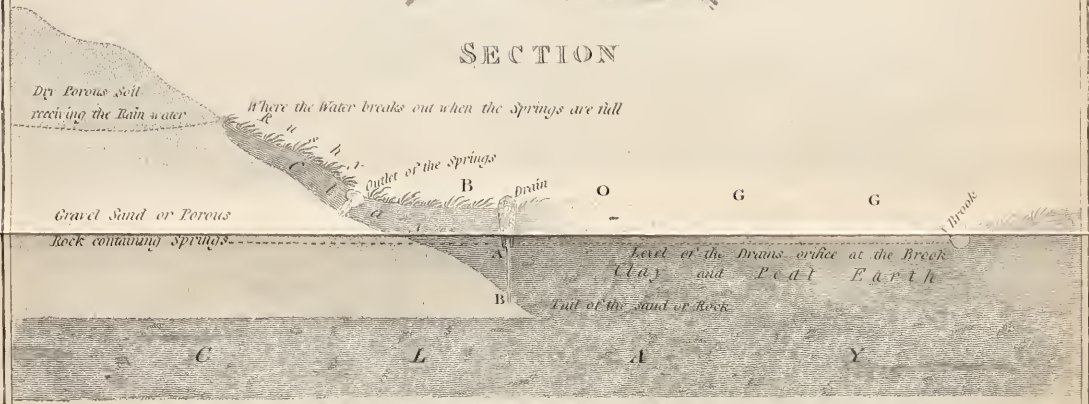
Neele sculp. Strand

N.° 2.

PLAN representing the DRAINAGE of BOGGS caused by SPRINGS.

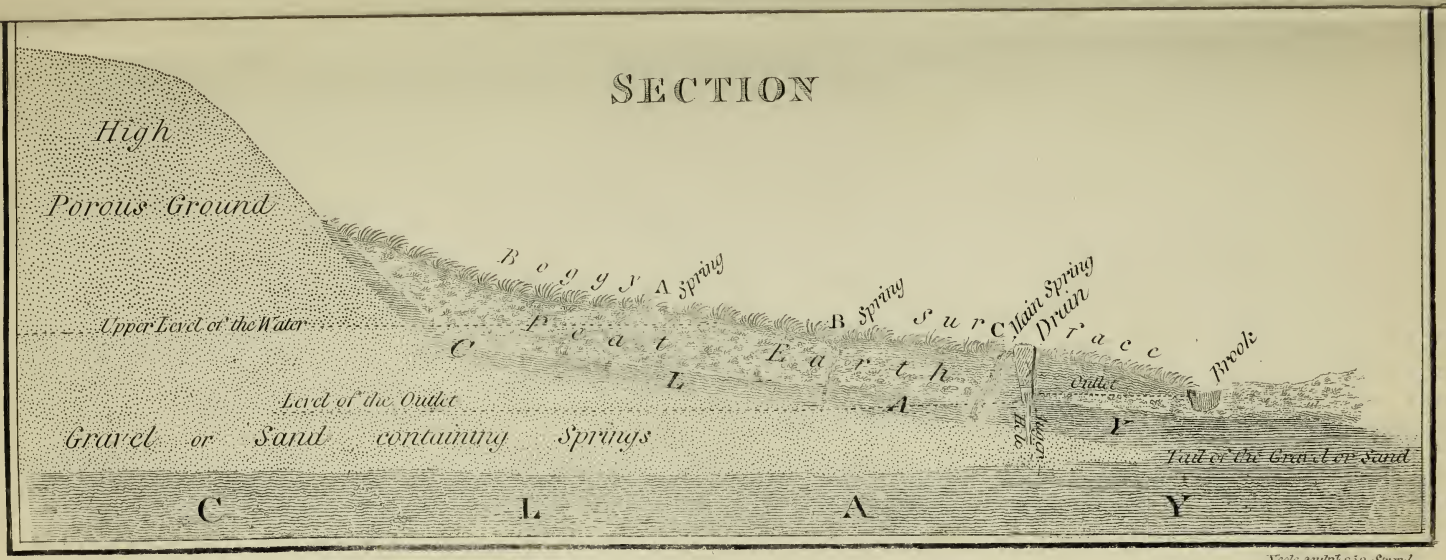
Class 1st

SECTION



If the stratum of Clay where the Trench is cut, be thicker than the Level of the Orifice will admit the Depth of the Drain to be, (A representing the Depth of it at that Level,) the remaining part of that Clay from A. to B. must be perforated by the Auger to the Tail or lowest point of the Sand or Rock at B, when the Spring will immediately rise up into the Trench by the pressure of its waters above the Drain's Level.

J. Johnston del.



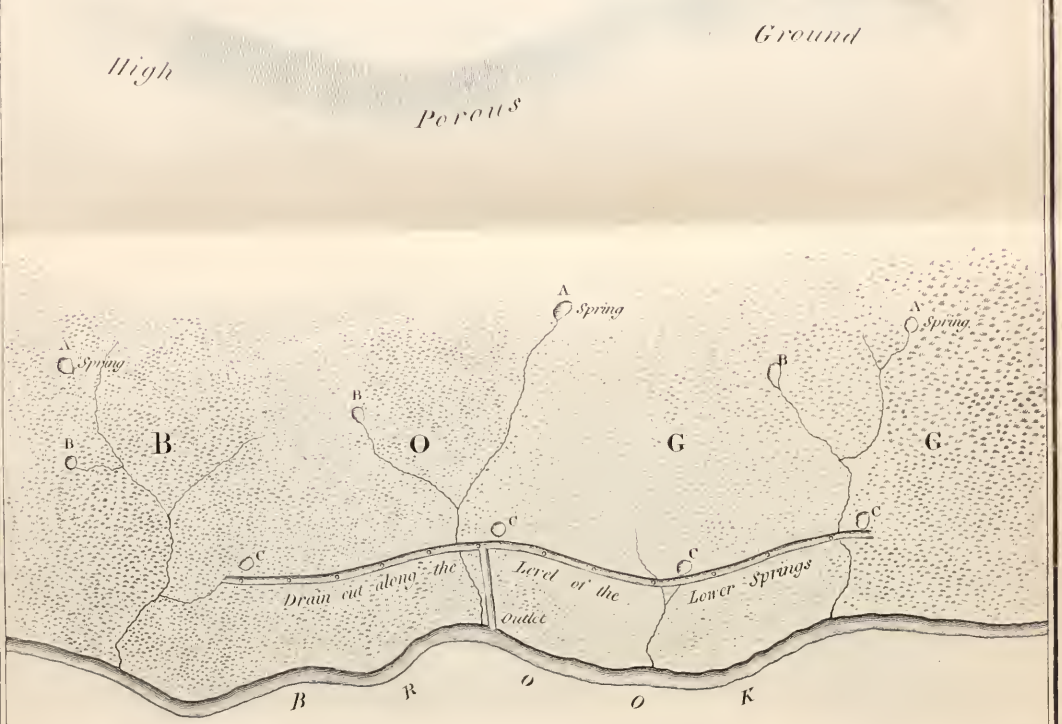
J. Johnston del.t

Neele sculp.t 352 Strand.

N°3.

DRAINAGE of SPRING BOGGS.

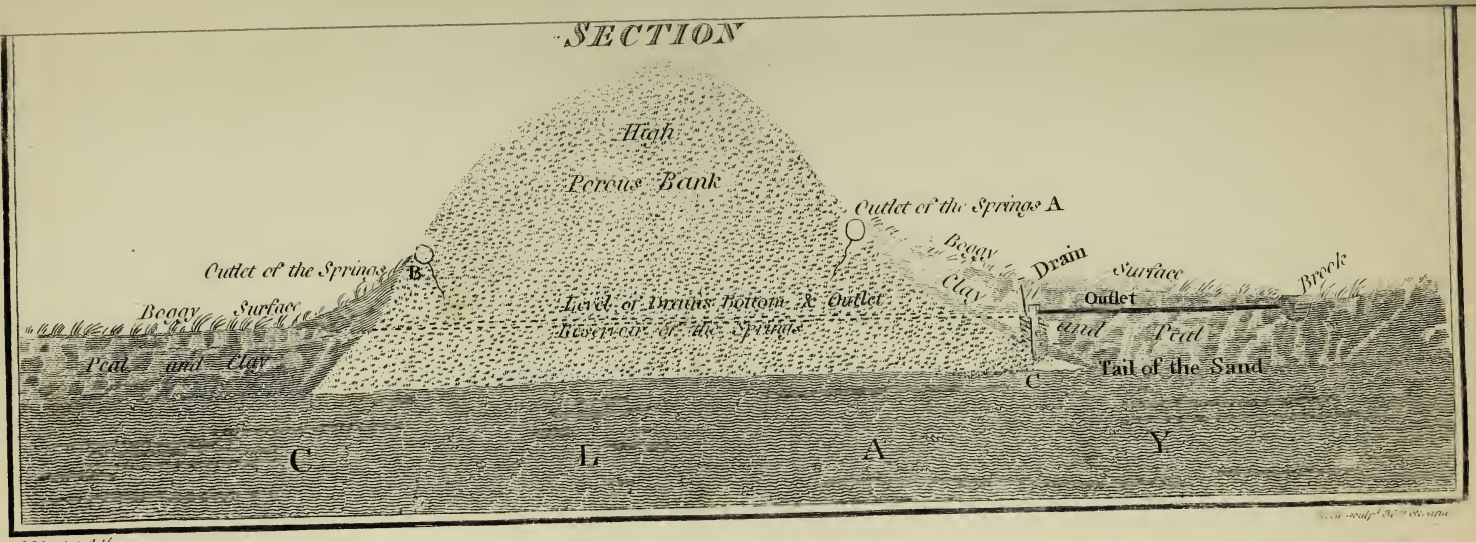
Class 2.d



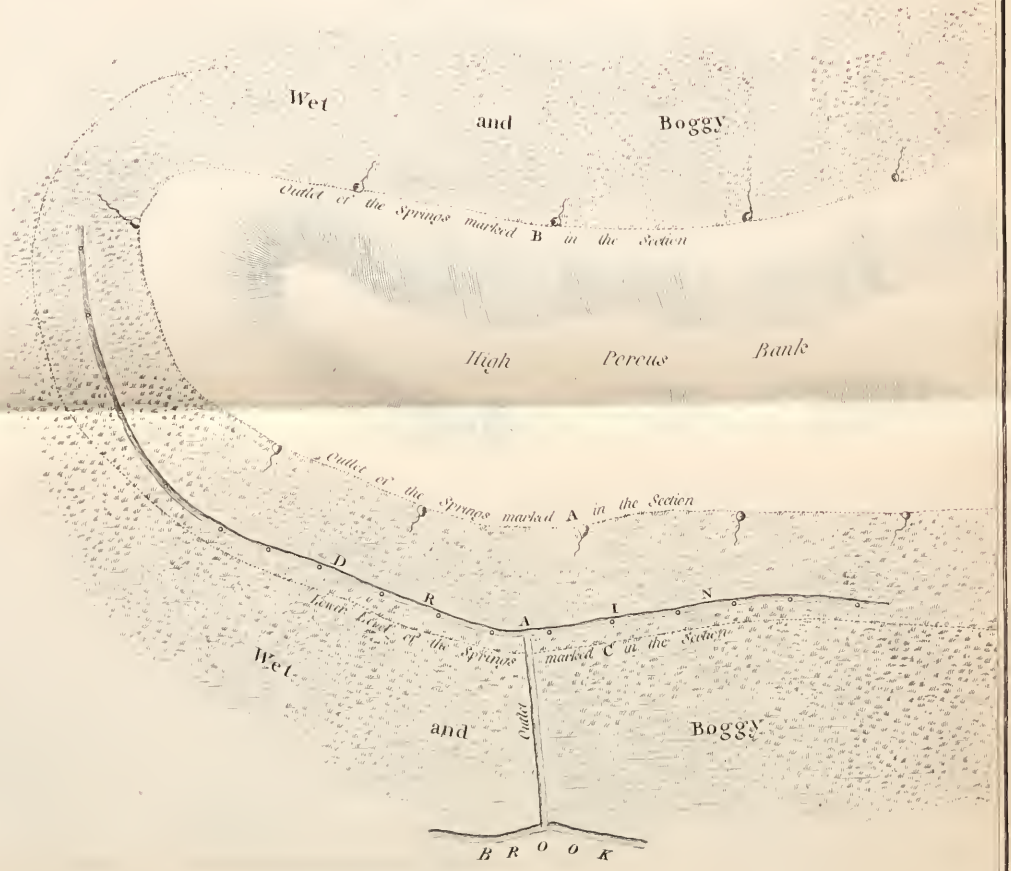
SECTION

A Johnston del.t

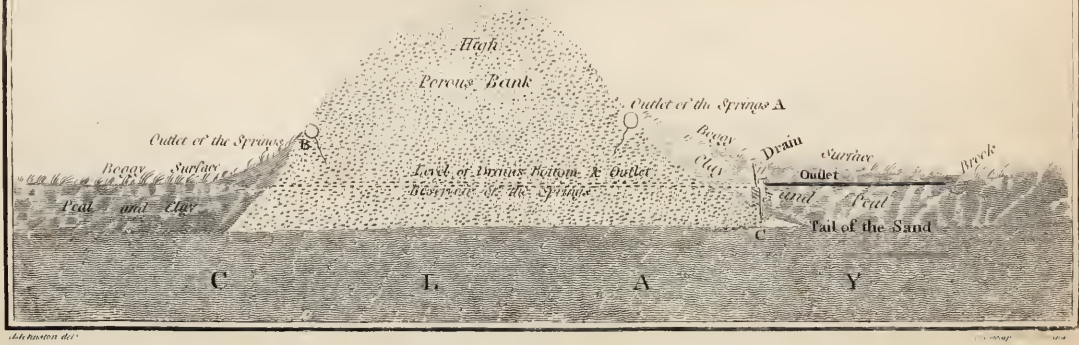
Veale Sculp.t 5, Wine Street.

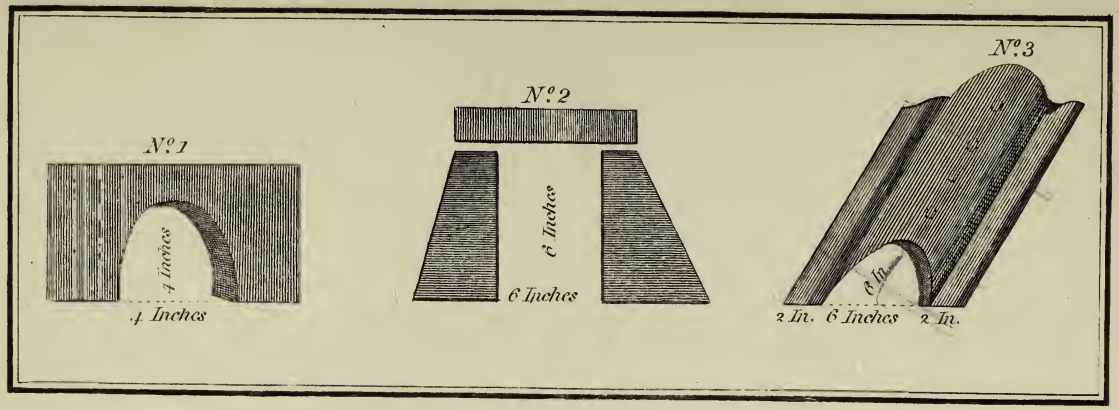

SECTION
High
Porous Bank
Outlet of the Springs A
Outlet of the Springs B
Boggy Surface
Peat and Clay
Level of Drains Bottom & Outlet
Reservoir of the Springs
Boggy Clay
Drain
Surface
Outlet
Brook
Sand
Peat
Tail of the Sand
C
C L A Y
Johnston del!

Plan N°. 1th



SECTION




N°.1
4 Inches
4 Inches
N°.2
6 Inches
6 Inches
N°.3
2 In. 6 Inches 2 In.

PLAN . N.°5.

Fig. 1

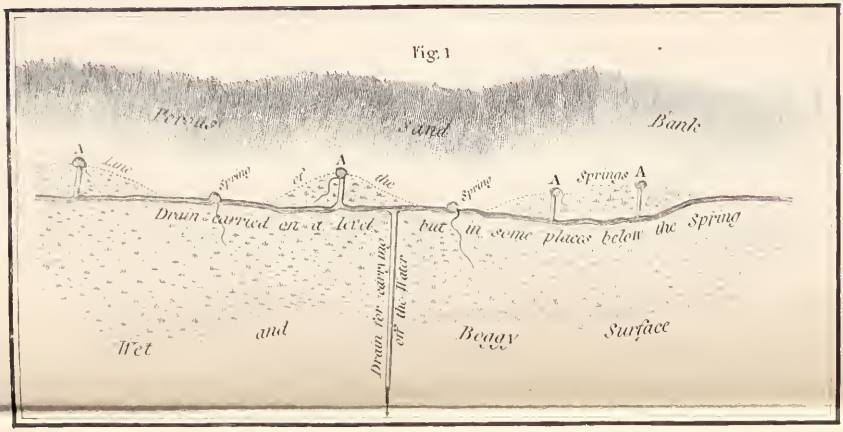
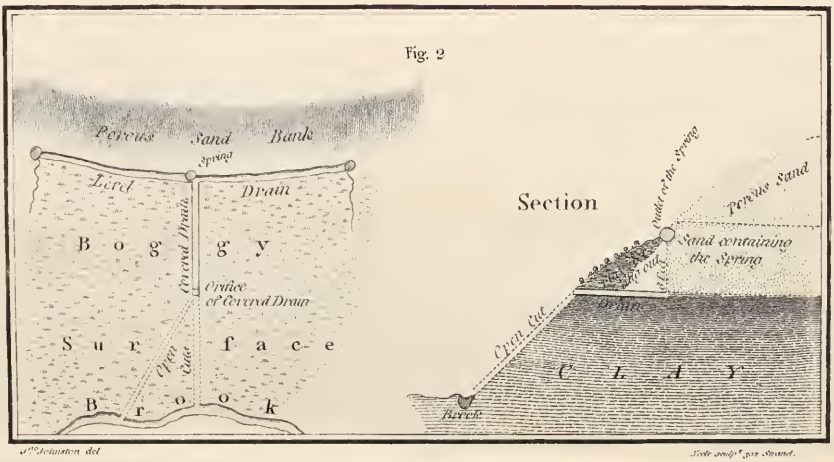
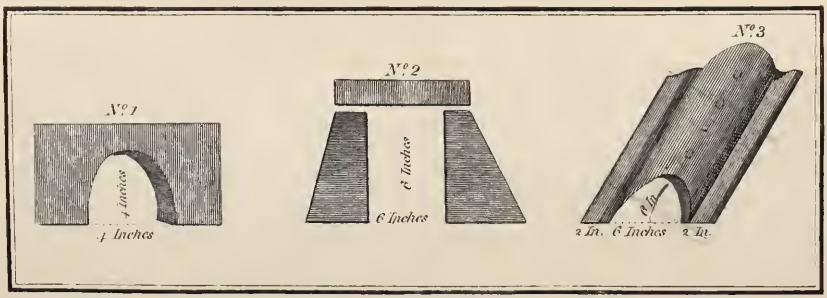


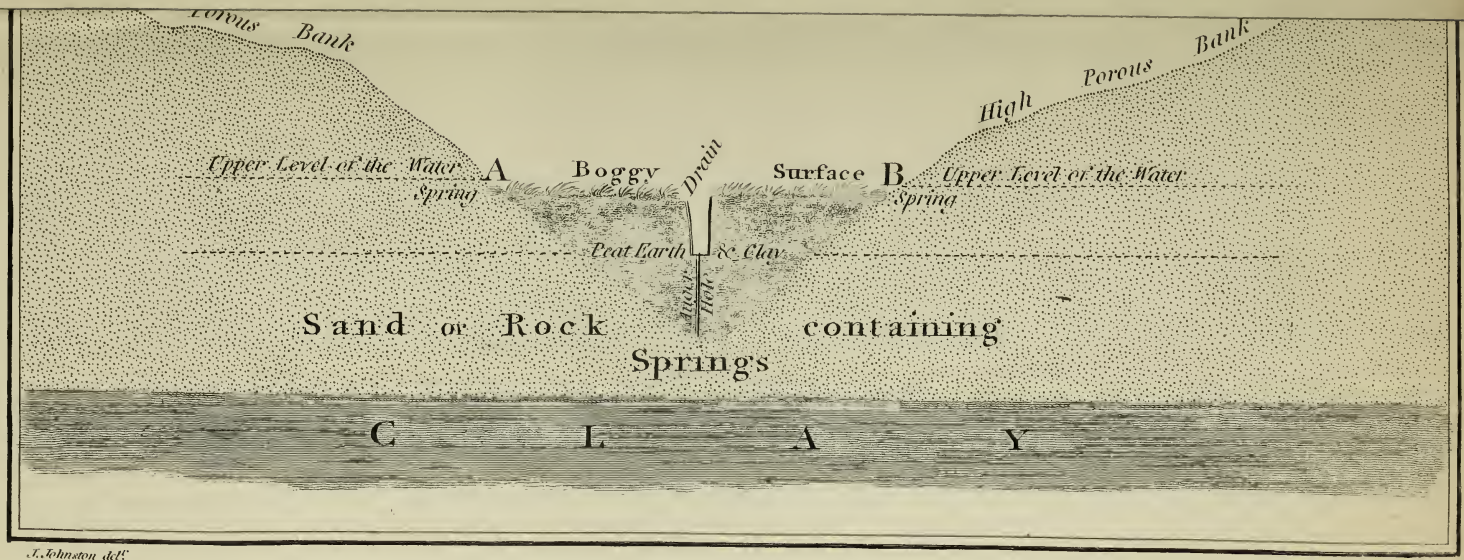
Fig. 2



J.ᵐᶜ Johnston del

Yeats sculp.ᵗ 301 Strand.



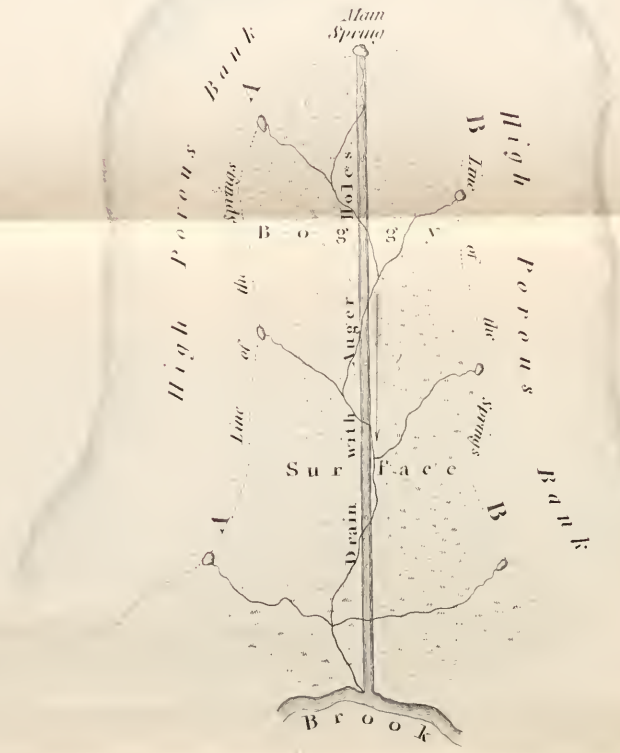


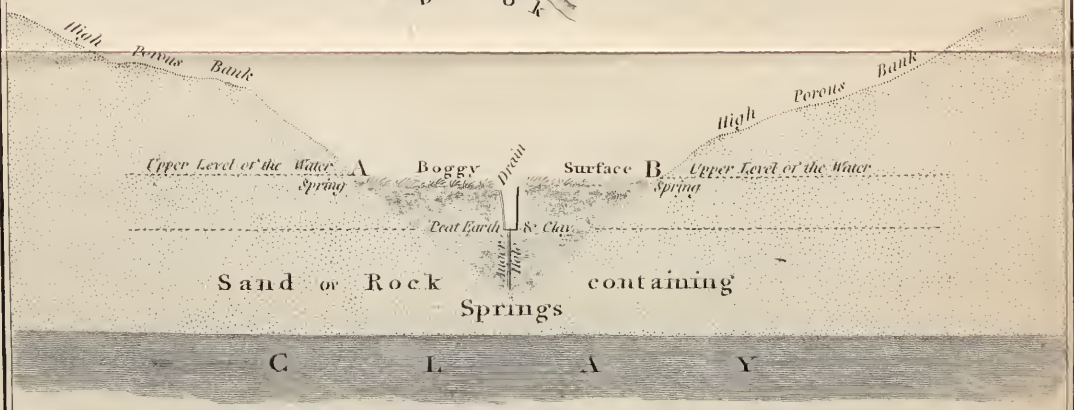
J. Johnston delt.

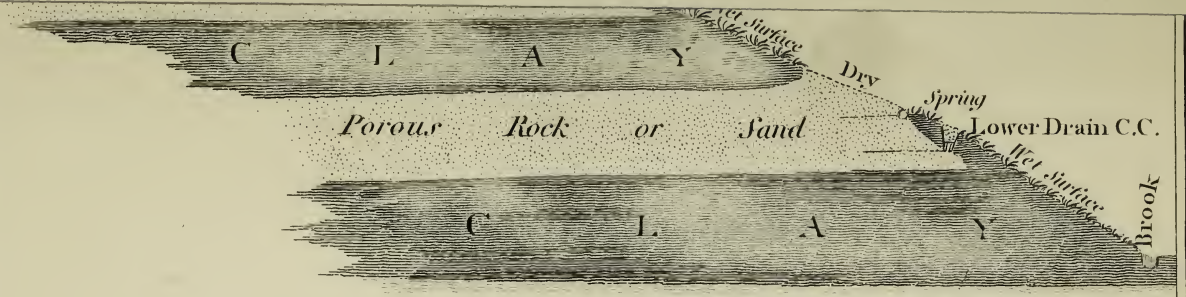
Neele sculpt. Strand

PLAN *representing the* DRAINAGE of BOGGS, *where the Sand Banks Unite.*

N°6th







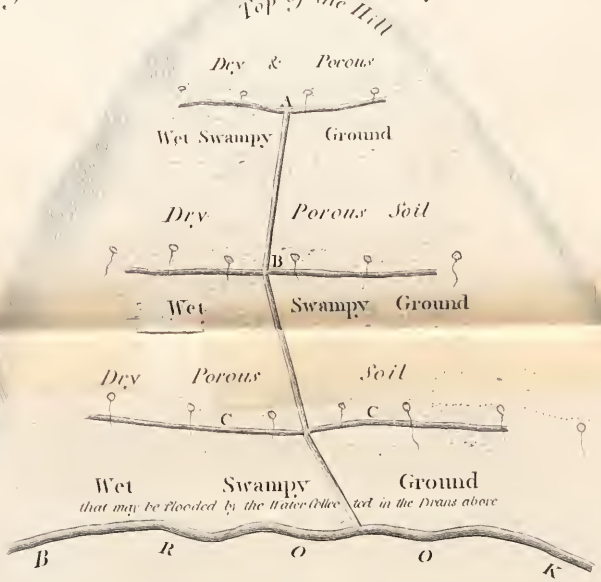
Explanation.

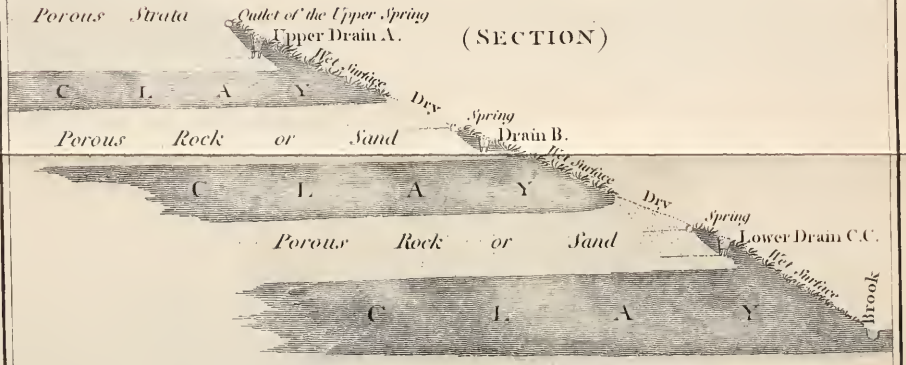
The covering of tough soil that overlaps the tail or lower part of the Stratum containing the Spring, is formed of the fine particles of earth washed down from the Soil above, by that part of the Rain which in heavy showers does not subside into the Ground. This accumulating upwards, is the cause why Springs back up, and why rushes & other Aquatics continue to vegetate higher up the Acclivity. The Drains being cut through this covering into the lower part of the Reservoir, reduce the top of the Springs, to a level so far below their former outlet, as entirely to prevent their afterwards overflowing the Ground below.

Jn.º Johnston del.º

Neele sculp.º Strand.

PLAN *representing the* DRAINAGE *of a* HILL *composed of alternate Beds of* Rock *and* Clay. N.° 7.

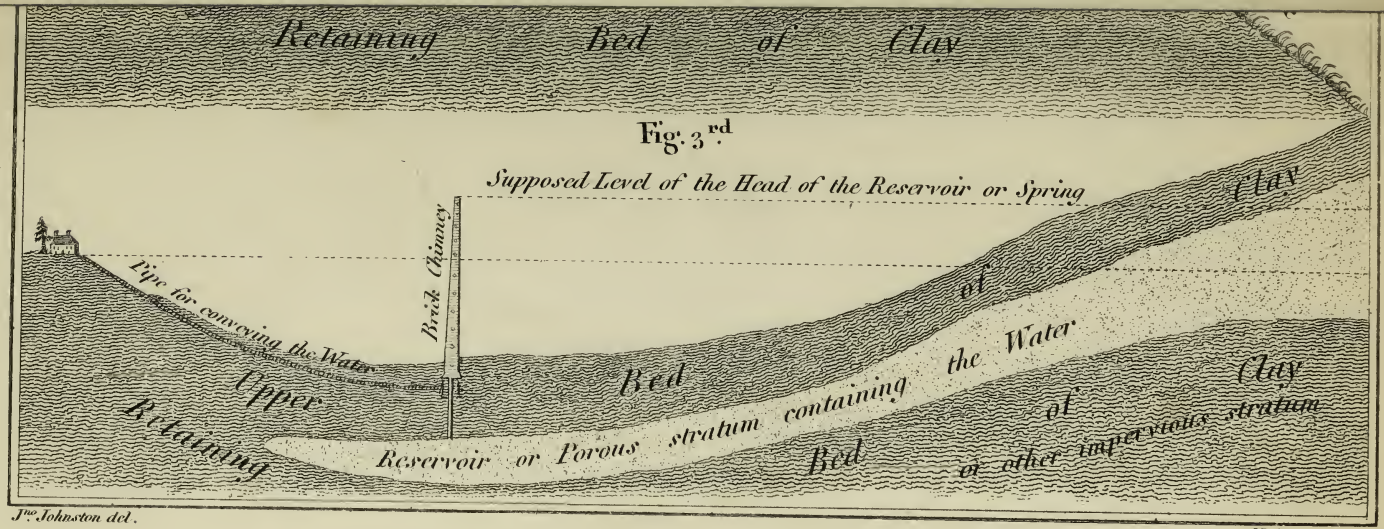




Explanation.

The covering of tough soil that overlays the tail or lower part of the Stratum containing the Spring, is formed of the fine particles of earth washed down from the Soil above, by that part of the Rain which in heavy showers does not subside into the Ground. This accumulating upwards, is the cause why Springs back up, and why rushes & other Aquatics continue to vegetate higher up the Acclivity. The Drains being cut through this covering into the lower part of the Reservoir, reduce the top of the Springs, to a level so far below their former outlet, as entirely to prevent their afterwards overflowing the Ground below.

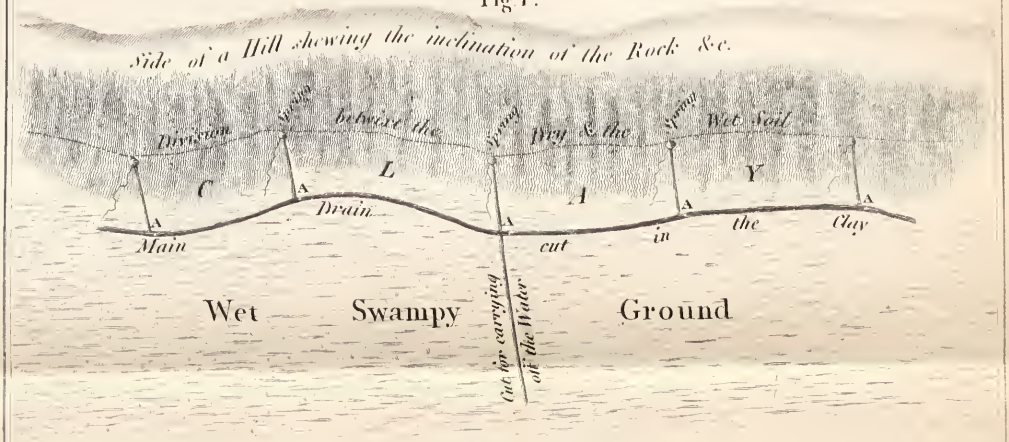
Jn.° Johnston del.t Neale sculp.t Strand.



Jno. Johnston del.

Neele sc. Strand

Fig 1st



SECTION OF A HILL

Fig. 2nd

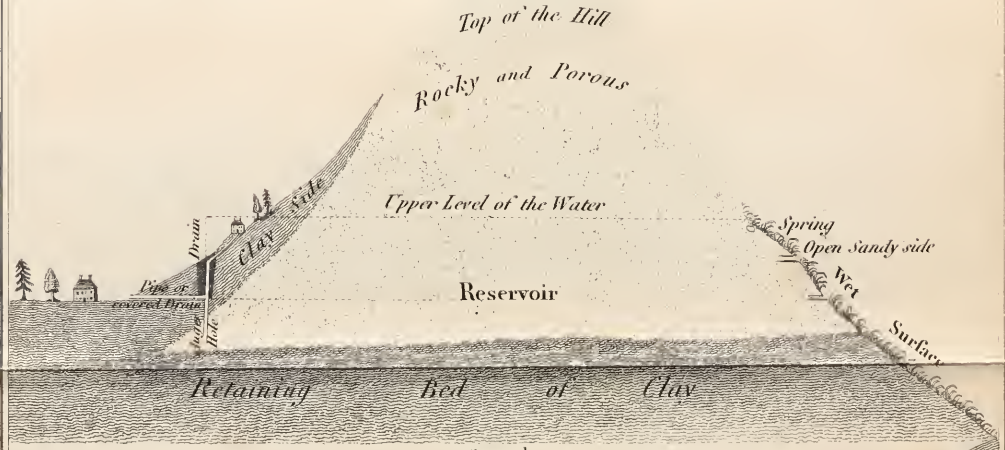
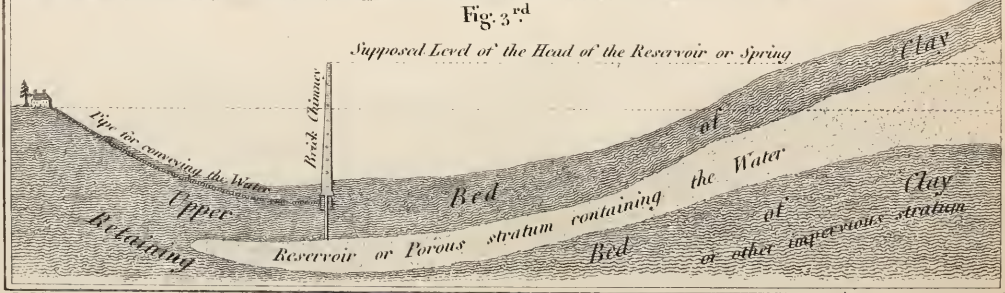
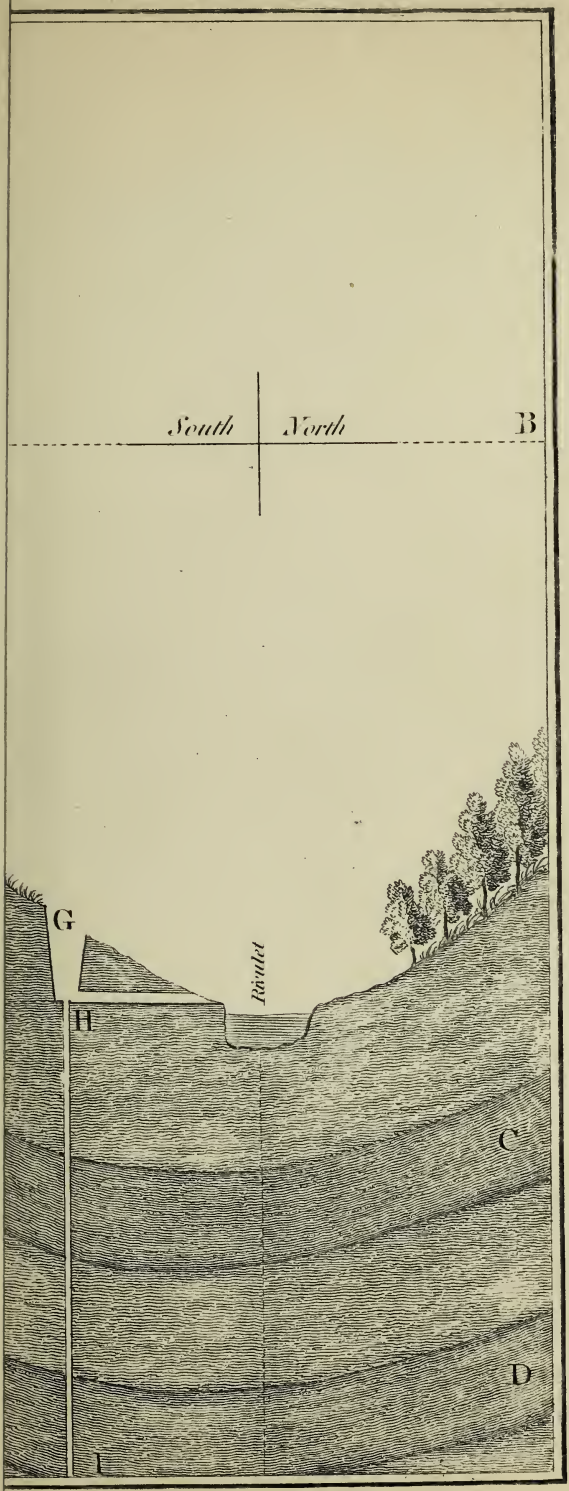


Fig. 3rd

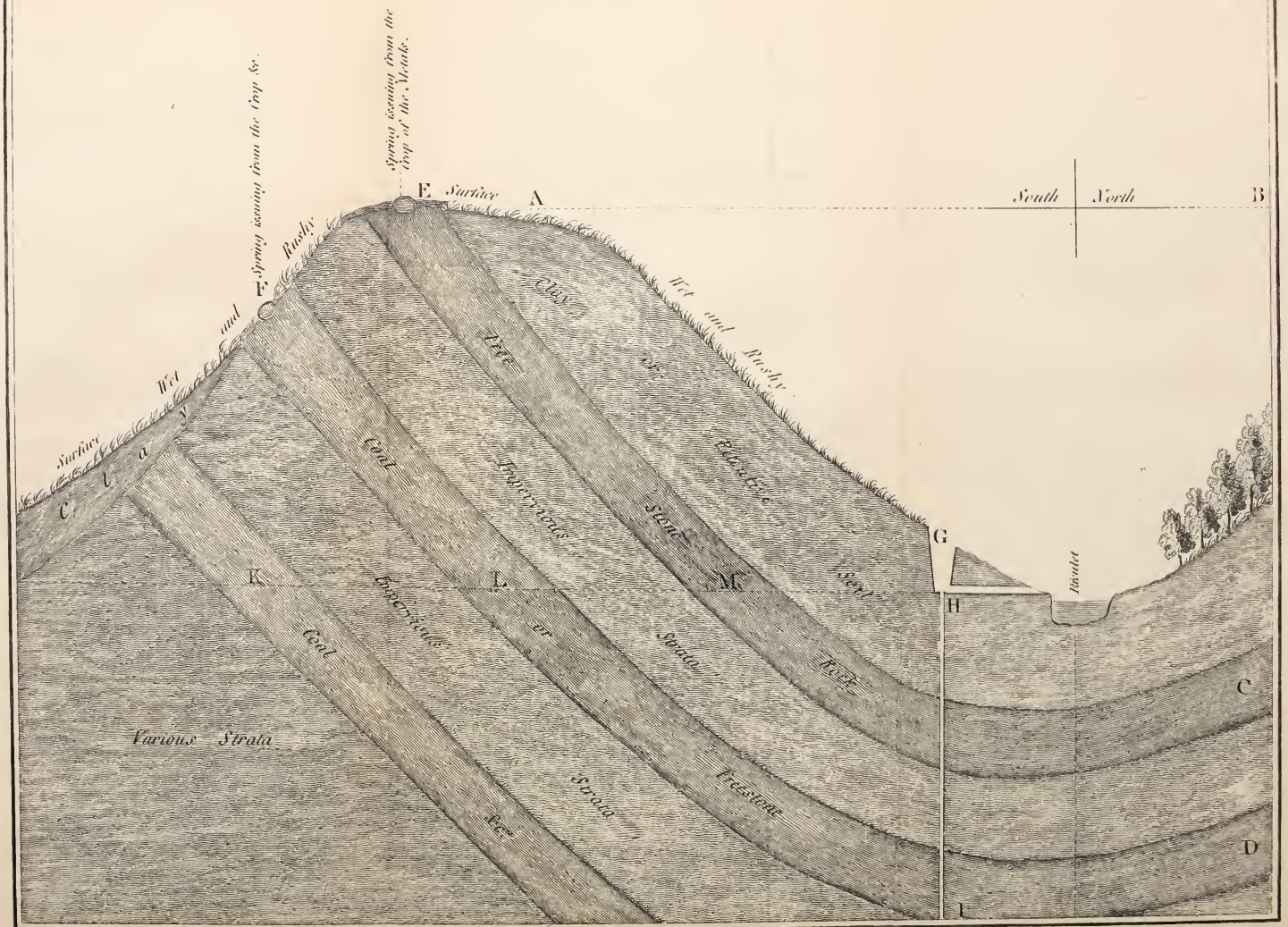

Supposed Level of the Head of the Reservoir or Spring
Clay
Pipe for conveying the Water
Brick Chimney
Upper Retaining Bed of Clay
Reservoir or Porous stratum containing the Water
Bed of other impervious stratum

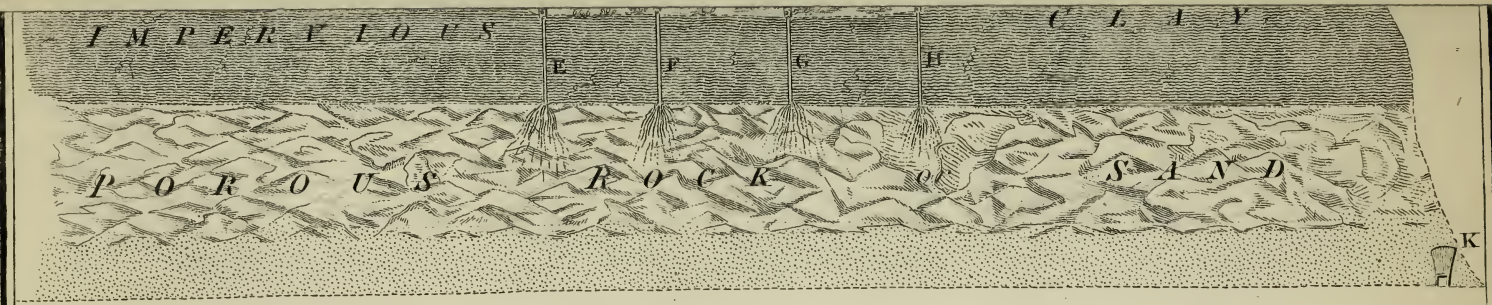
Jno Johnston del.

Neale sc Strand


South
North
B
G
Rivulet
H
C
D
L

Plan. 1st 9.


Spring issuing from the top &c.
Spring issuing from the top of the Vessels.
Rushy
E
Surface
A
South
North
B
F
and
Wet
Surface
Clay
C
Clay
Fire
Clay
Wet and Rushy
Coal
Impressions
Stone
Earth
G
Gravel
M
H
Coal
Impressions
L
Strata
Rock
Various Strata
Strata
Freestone
Rock
C
D
I
K
J Johnstone del.



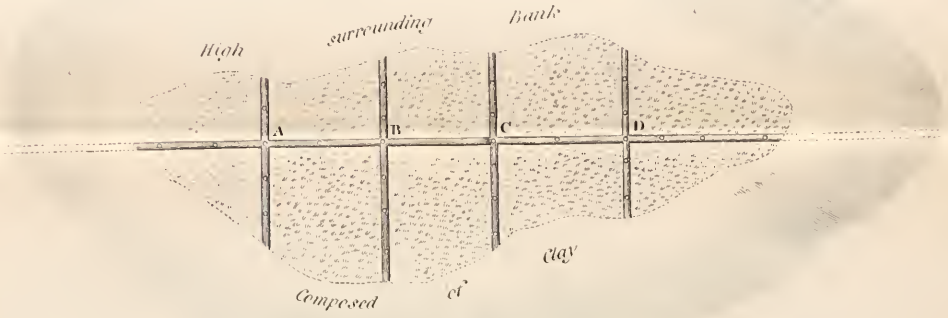
The letters **A.B.C.D.** *in the Section correspond to those in the Surface View, and represent the Drains cut thro' the Peat earth & filled up with loose Stones to within a foot & half of the top* **E.F.G.H.** *represent the perforation of the Clay by the Auger holes, and the descent of the water into the Rock below*

J. Johnston del.

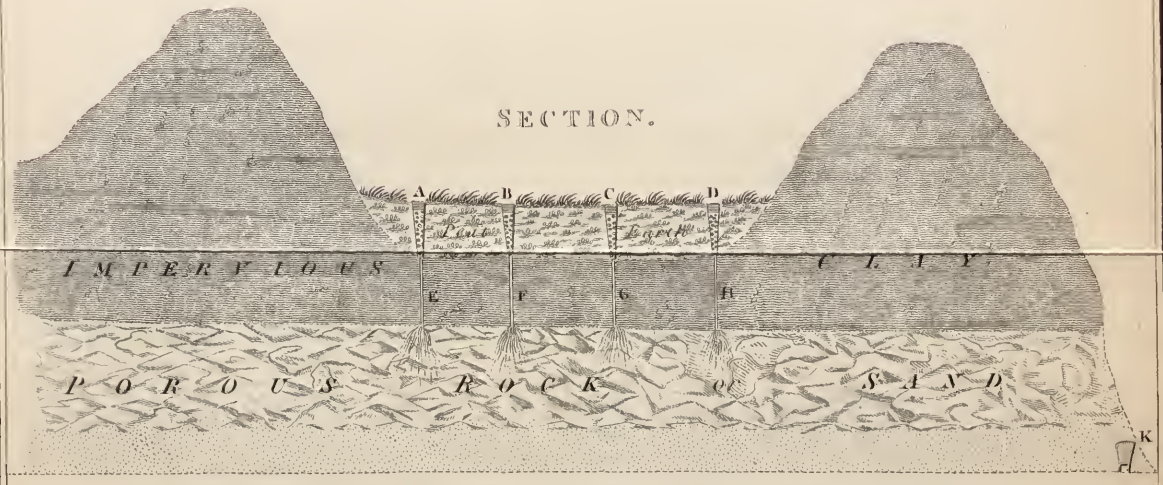
Neele sculp.t Strand

PLAN *representing the Drainage of a* Bog *or piece of Marshy Ground by perforating through an impervious to a porous sub stratum*

N°10.



SECTION.



The letters **A.B.C.D.** *in the Section correspond to those in the Surface View, and represent the Drains cut thro' the Peat earth & filled up with loose Stones to within a foot & half of the top* **E.F.G.H.** *represent the perforation of the Clay by the Auger holes, and the descent of the water into the Rock below*

J. Johnston del.

Neele sculp. Strand

Sand
Clay
Sand
Clay
Drawn out in the bottom Part of
Drawn out in the bottom
Wet Clay and Sand
Wet Clay and Sand
Drawn
Drawn
Out
Out
J. Johnson del.
S. Tyde sculp.

Fig.1st

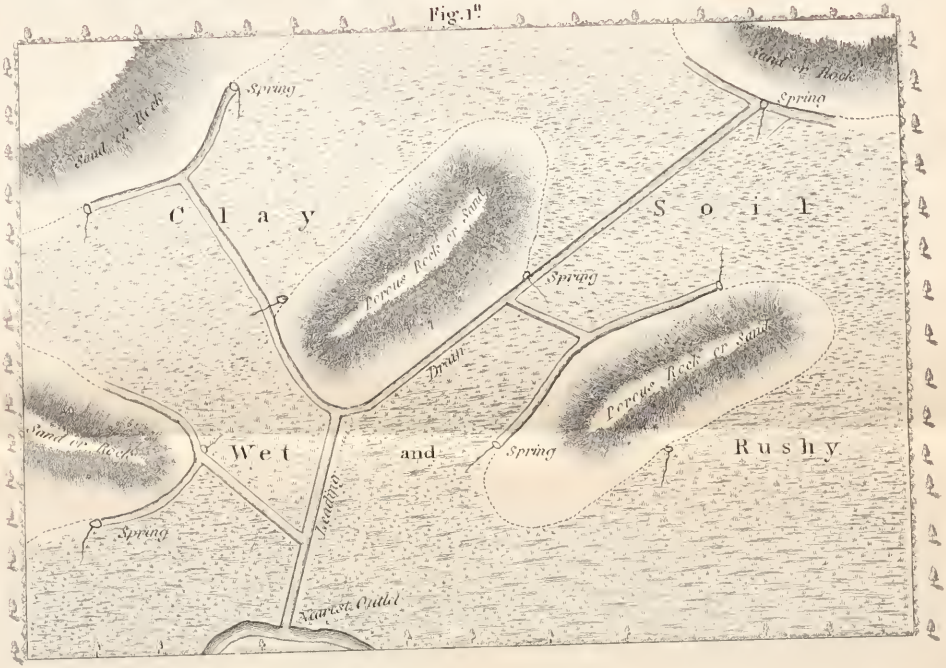
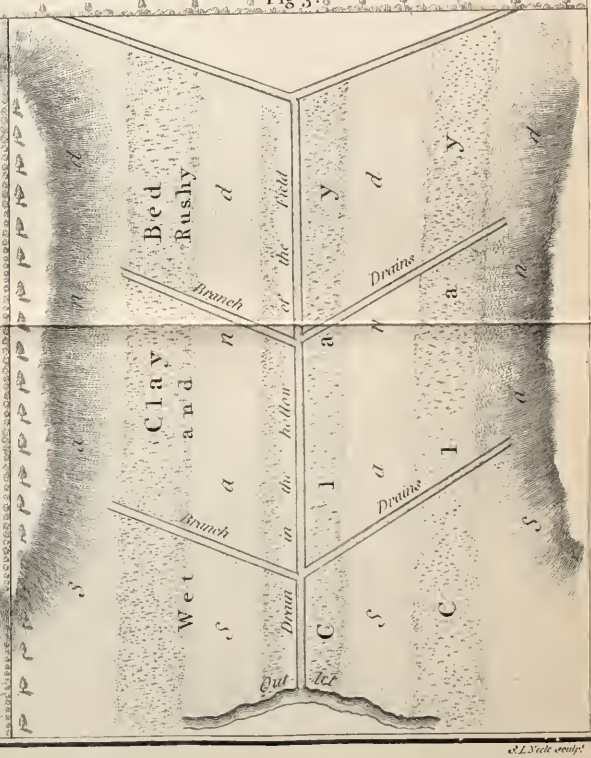


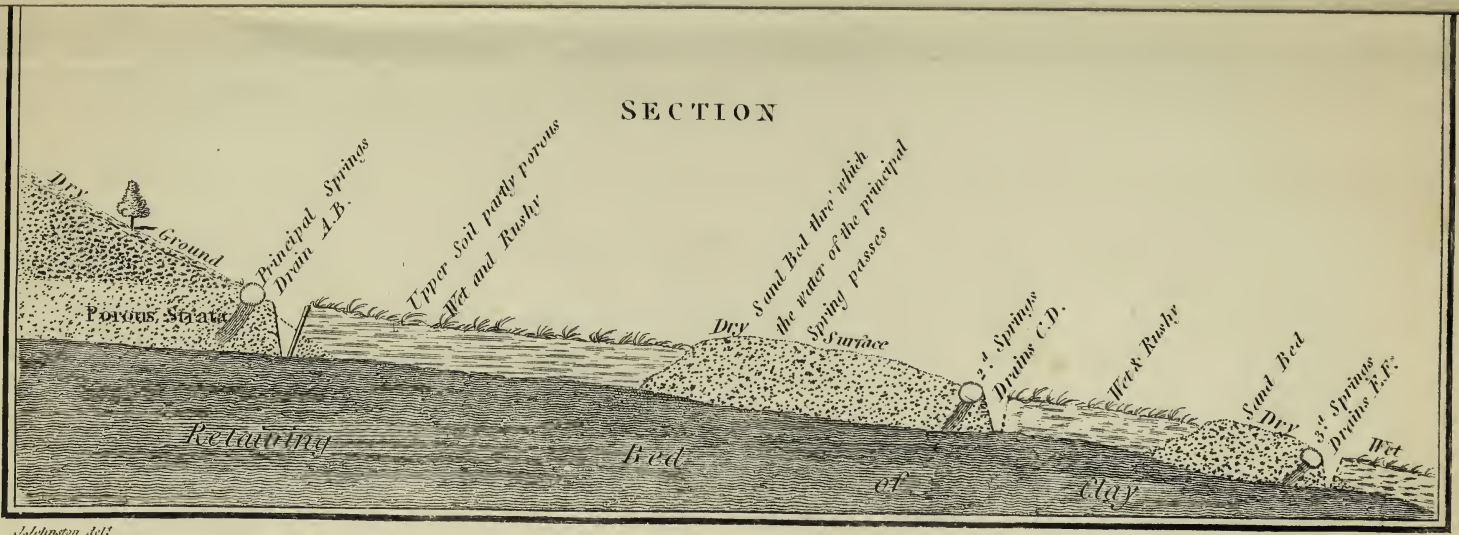
Fig.2d

Fig 3d

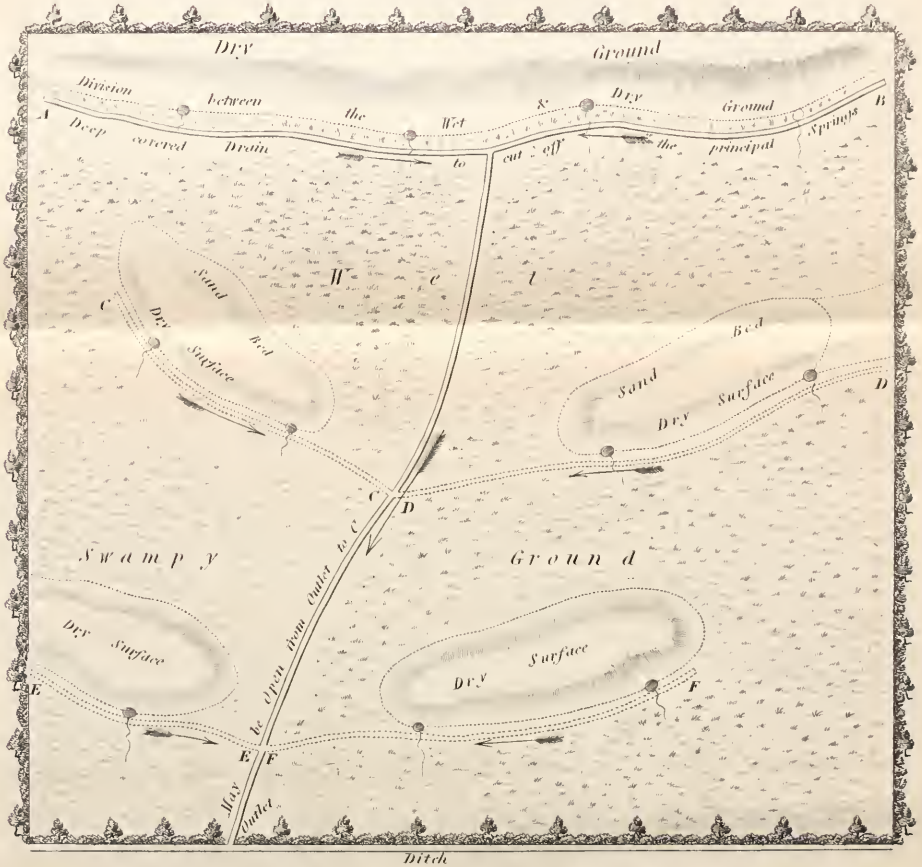


J. Johnston del.

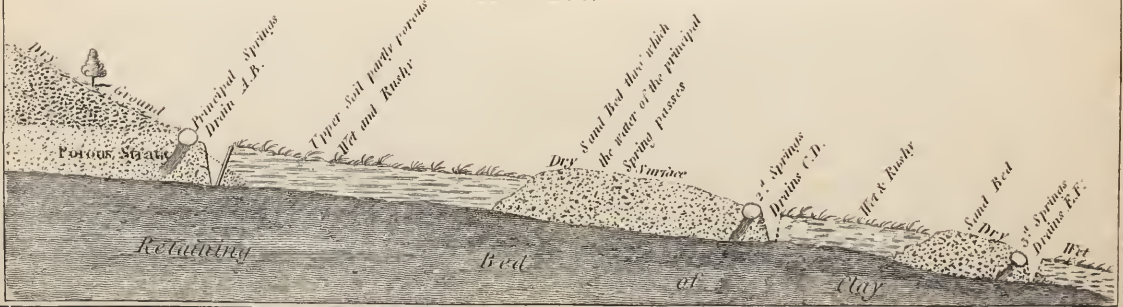
S.J. Neele sculp.


SECTION
Dry
Ground
Principal Springs
Drain A.B.
Porous Strata
Upper Soil partly porous
Wet and Rushy
Dry
Sand Bed thro' which
the water of the principal
Spring passes
Surface
2.d Springs
Drains C.D.
Wet & Rushy
Sand Bed
Dry
3.d Springs
Drains E.F.
Wet
Retaining
Bed
of
Clay
J.Johnston del.t
S.Neele Sculp.

PLAN . N°72

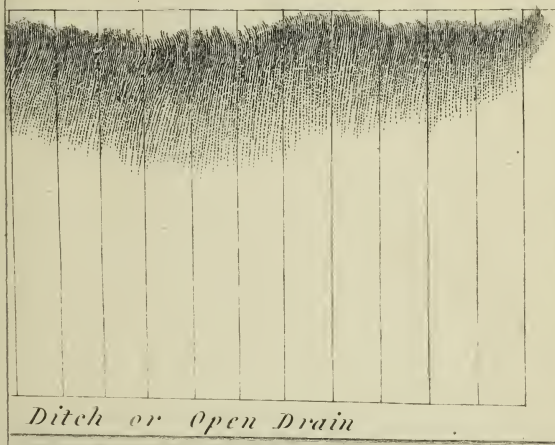


SECTION



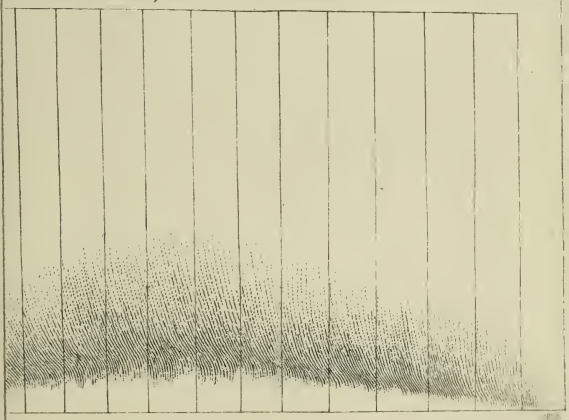
LIBRARY
ILLINOIS.

Fig. 1.



Ditch or Open Drain

in the hollow part of the Field



PLAN, N.º 23.

Fig. 3.

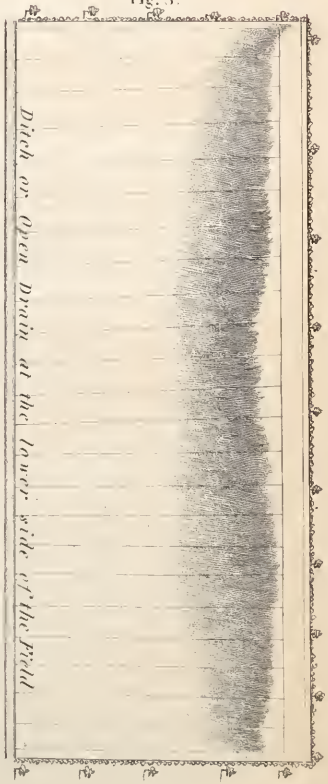


Fig. 2.

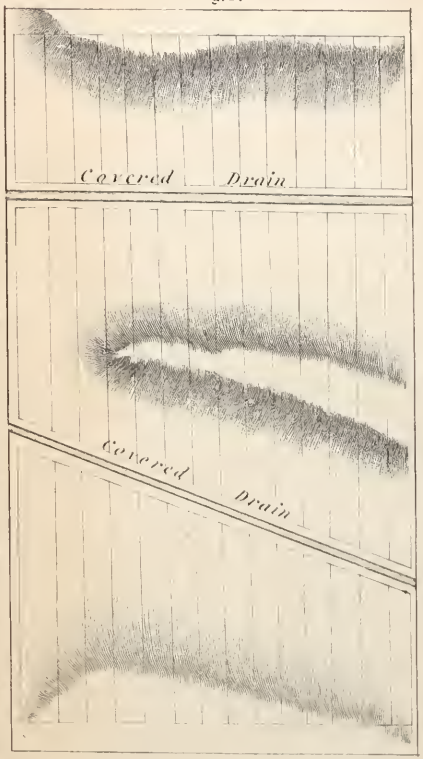
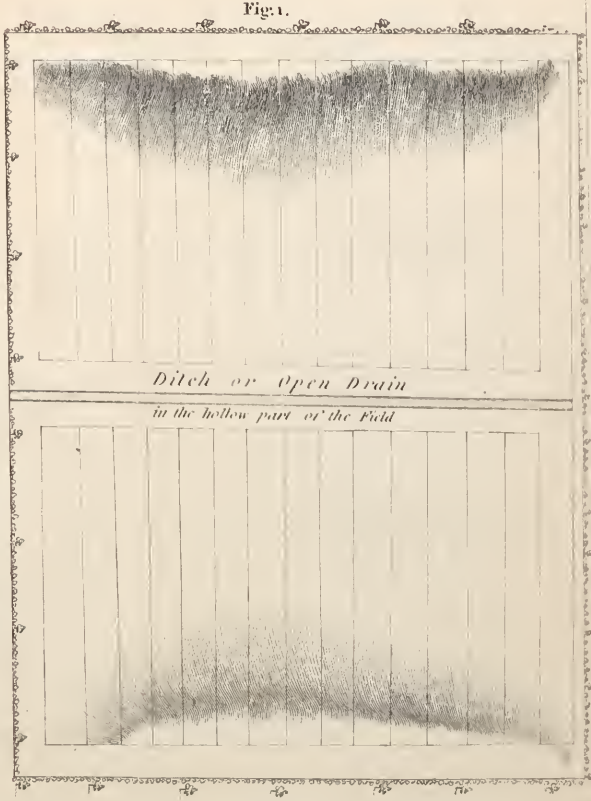


Fig. 1.



The small black lines represent the Ridges & Furrows inclining towards the Drains.

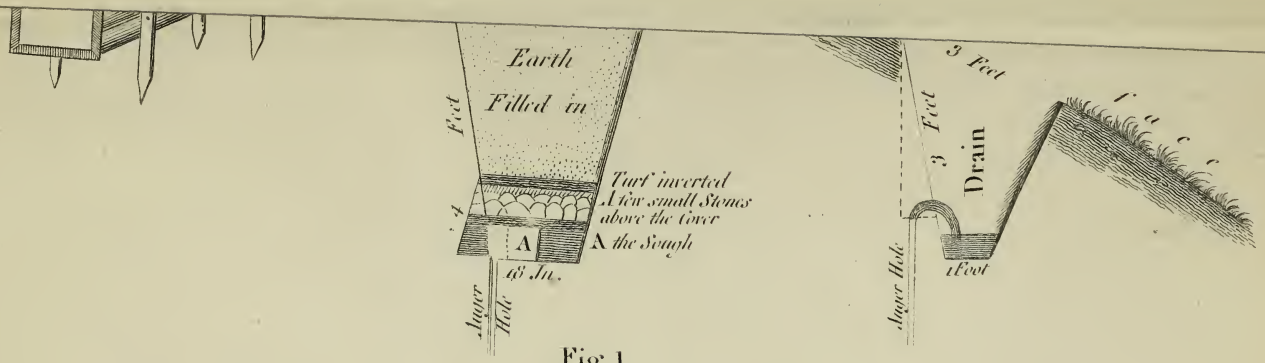
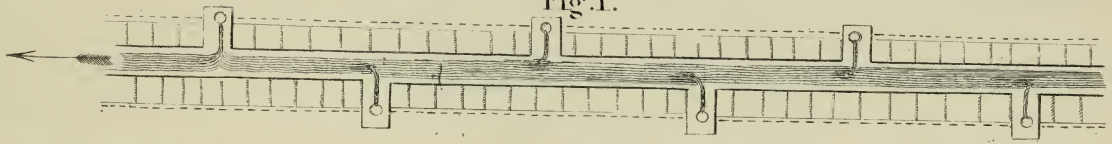


Fig. 1.



J. Johnston del.

S. Neele sculp.

Plan. Pl. 4.

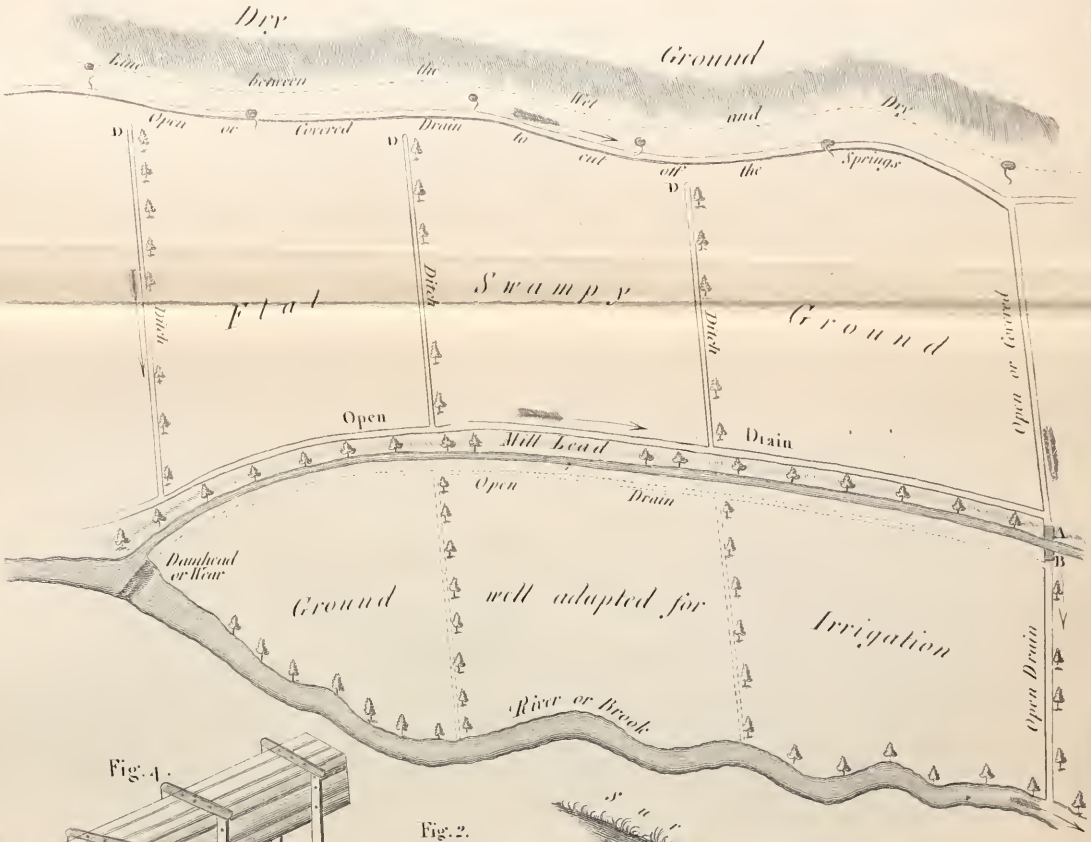


Fig. 4.

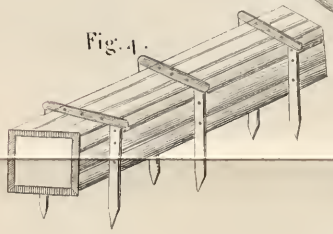


Fig. 2.

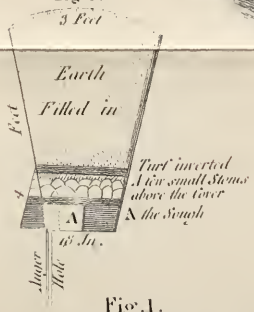


Fig. 3.

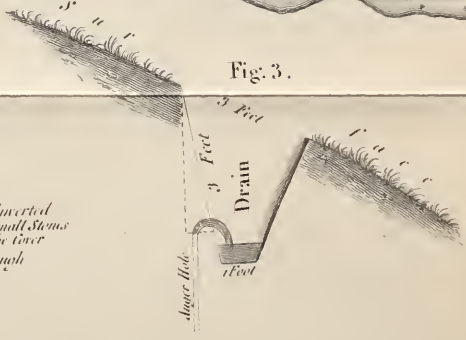
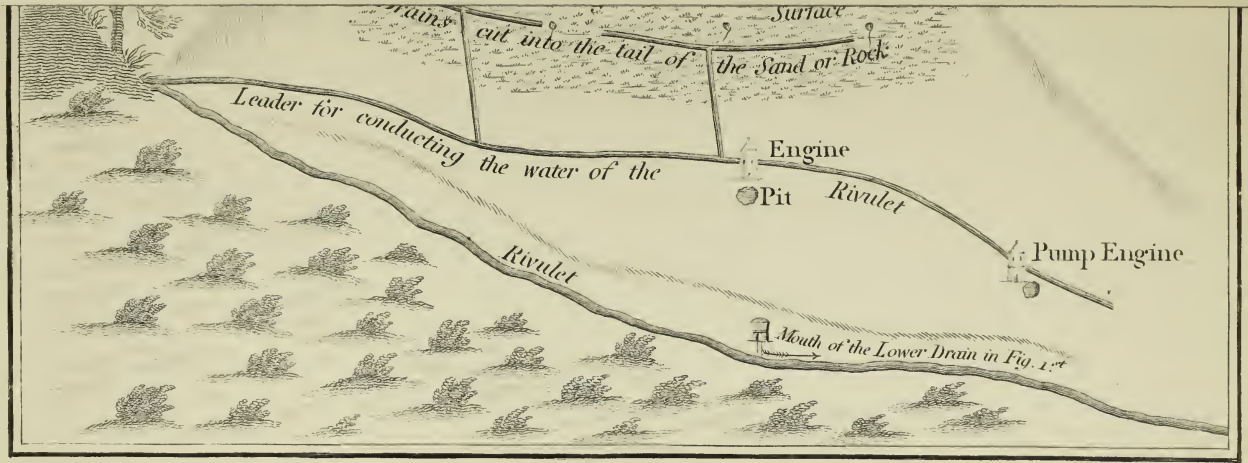


Fig. 1.



Jn.o Johnston del.t

Neele sculp.t Strand.

PLAN representing the DRAINAGE of MINES &c.

N.B.

(SECTION Fig.1st)

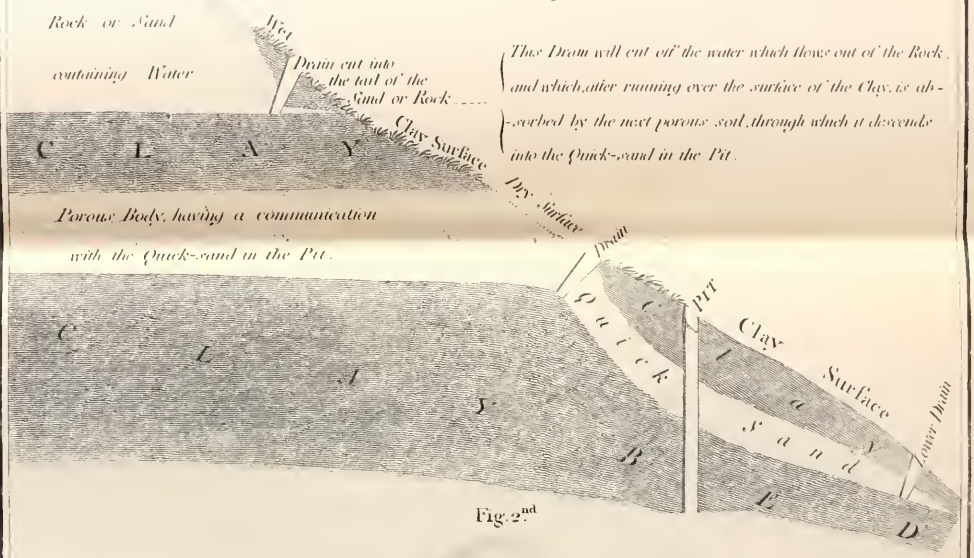
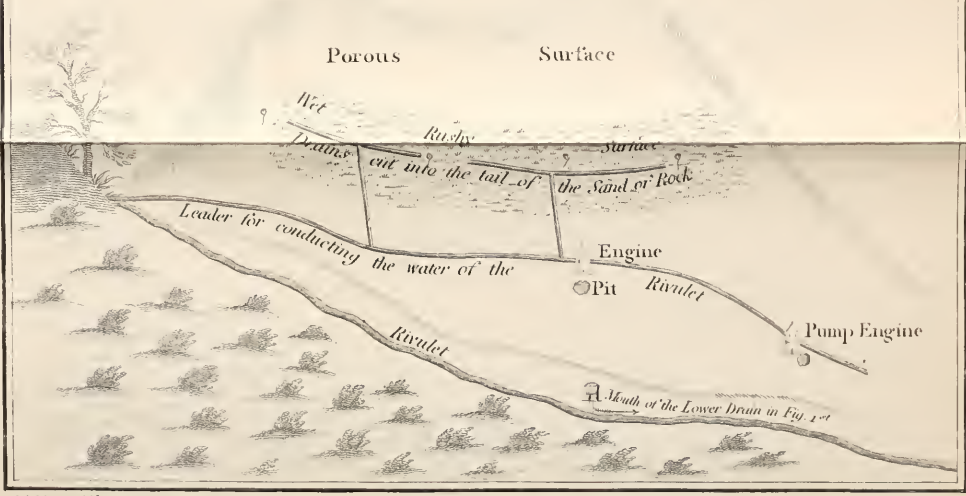
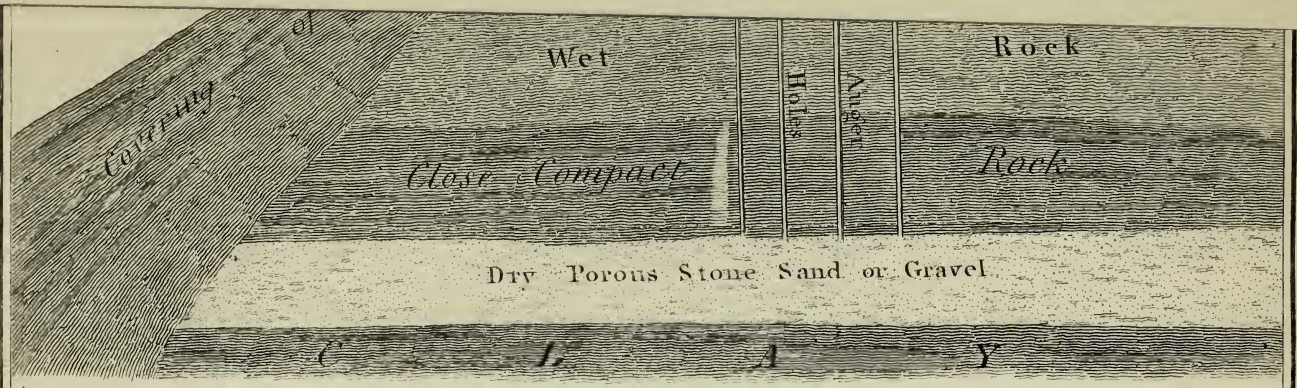

Rock or Sand
containing Water
Wet
Drain cut into the tail of the Sand or Rock
This Drain will cut off the water which flows out of the Rock, and which, after running over the surface of the Clay, is absorbed by the next porous soil, through which it descends into the Quick-sand in the Pit.
C L A Y
Clay Surface
Dry Surface
Porous Body, having a communication with the Quick-sand in the Pit.
Drain
C L A Y
Quick
Pit
Clay
Land
Surface
Sand
Lower Drain
B
E
D

Fig.2nd



Jnº Johnston delt.

Neele sculpt. Strand.



Perhaps under this Clay Bed, there may be another dry porous Stratum into which the water may be let down, and reduced to a still lower level; and this may be ascertained by boring an Auger Hole thro' the Clay.

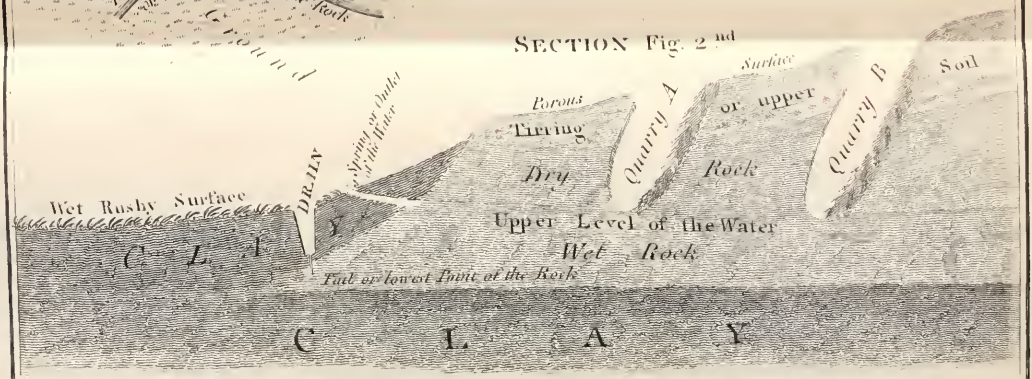
J.ⁿ Johnston del.ᵗ

Neele sculp.ᵗ Strand.

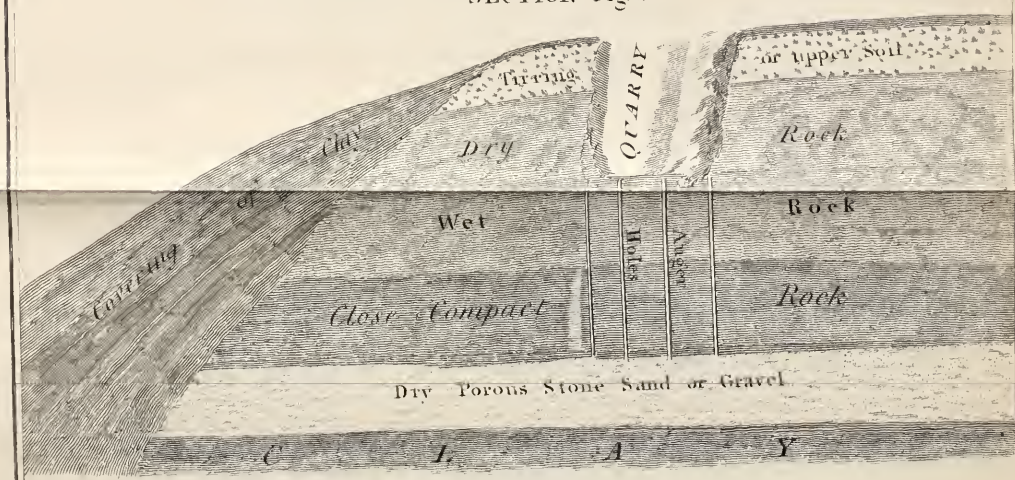
PLAN *representing the*
Drainage *of* Quarries
N°10

Fig. 1st

SECTION Fig. 2nd



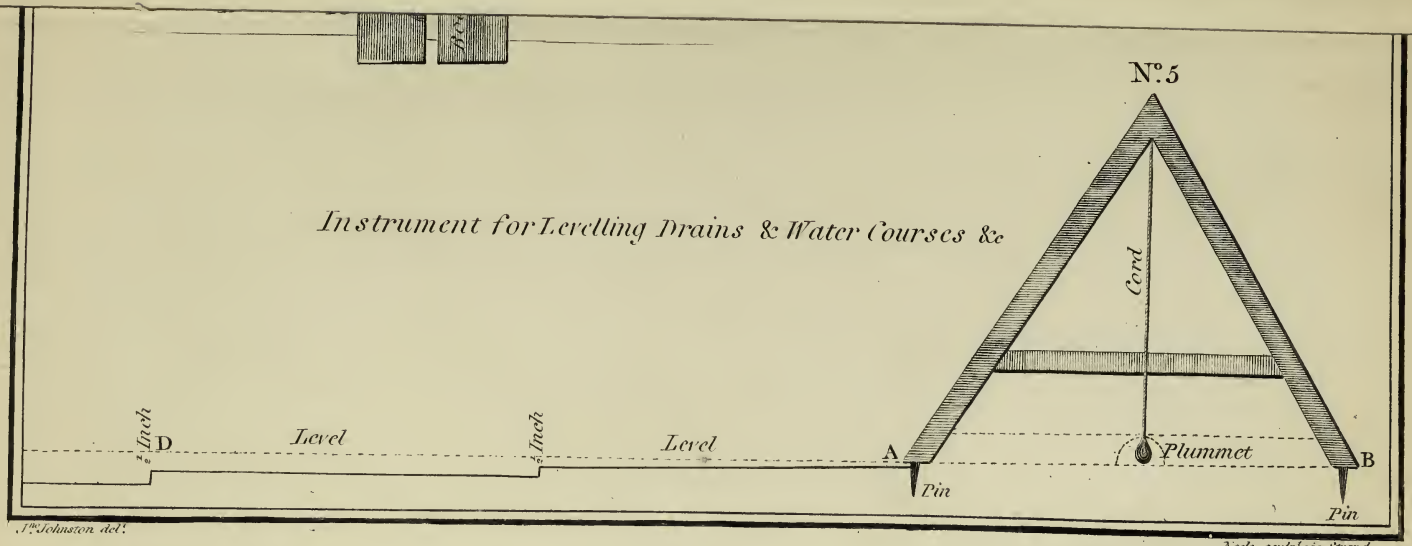
SECTION Fig. 3rd



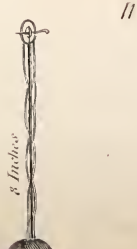
Perhaps under this Clay Bed, there may be another dry porous Stratum into which the water may be let down, and reduced to a still lower level; and this may be ascertained by boring an Auger Hole thro' the Clay.

J. Johnson del.

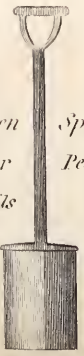
Neele sculp. Strand.


Nº.5
Instrument for Levelling Drains & Water Courses &c
Cord
Inch
D
Level
Inch
Level
A
Plummet
B
Pin
Pin
Jno Johnston del.
Neele sculp.t 356 Strand.

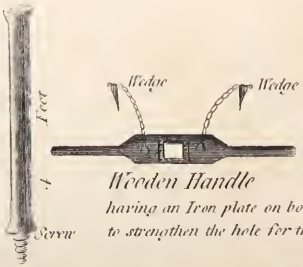
PLAN . N.° 17.



Instrument for cleaning the Auger.



Wooden Spade for Peat Soils



Wooden Handle having an Iron plate on both sides to strengthen the hole for the Rods.

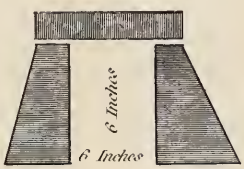
Iron Key

Iron Handle

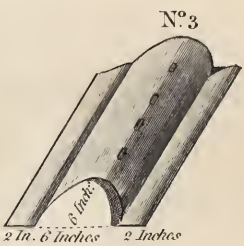
Bottom Shovel with edges turned up

N.° 1

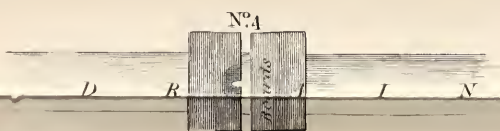
N.° 2



N.° 3

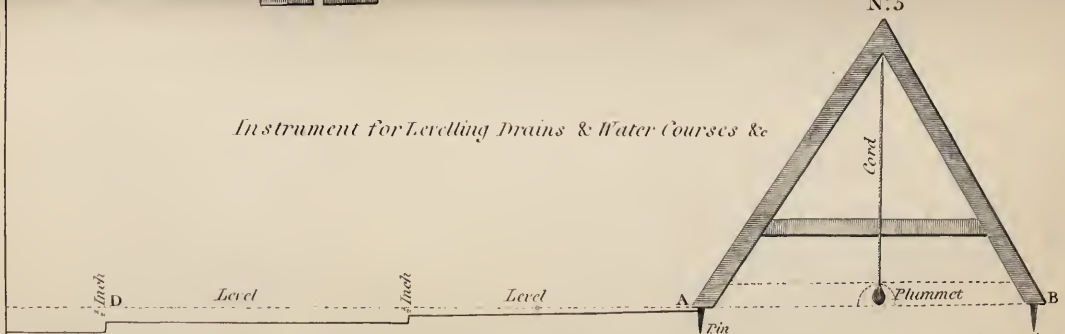


N.° 4



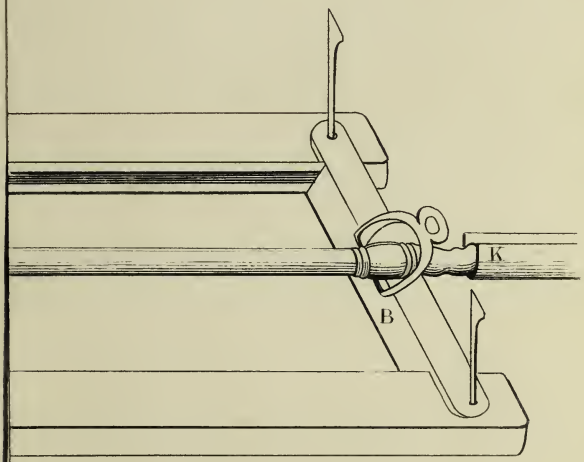
N.° 5

Instrument for Levelling Drains & Water Courses &c



J.ª Johnston del.

Neele sculp.ª 352 Strand.

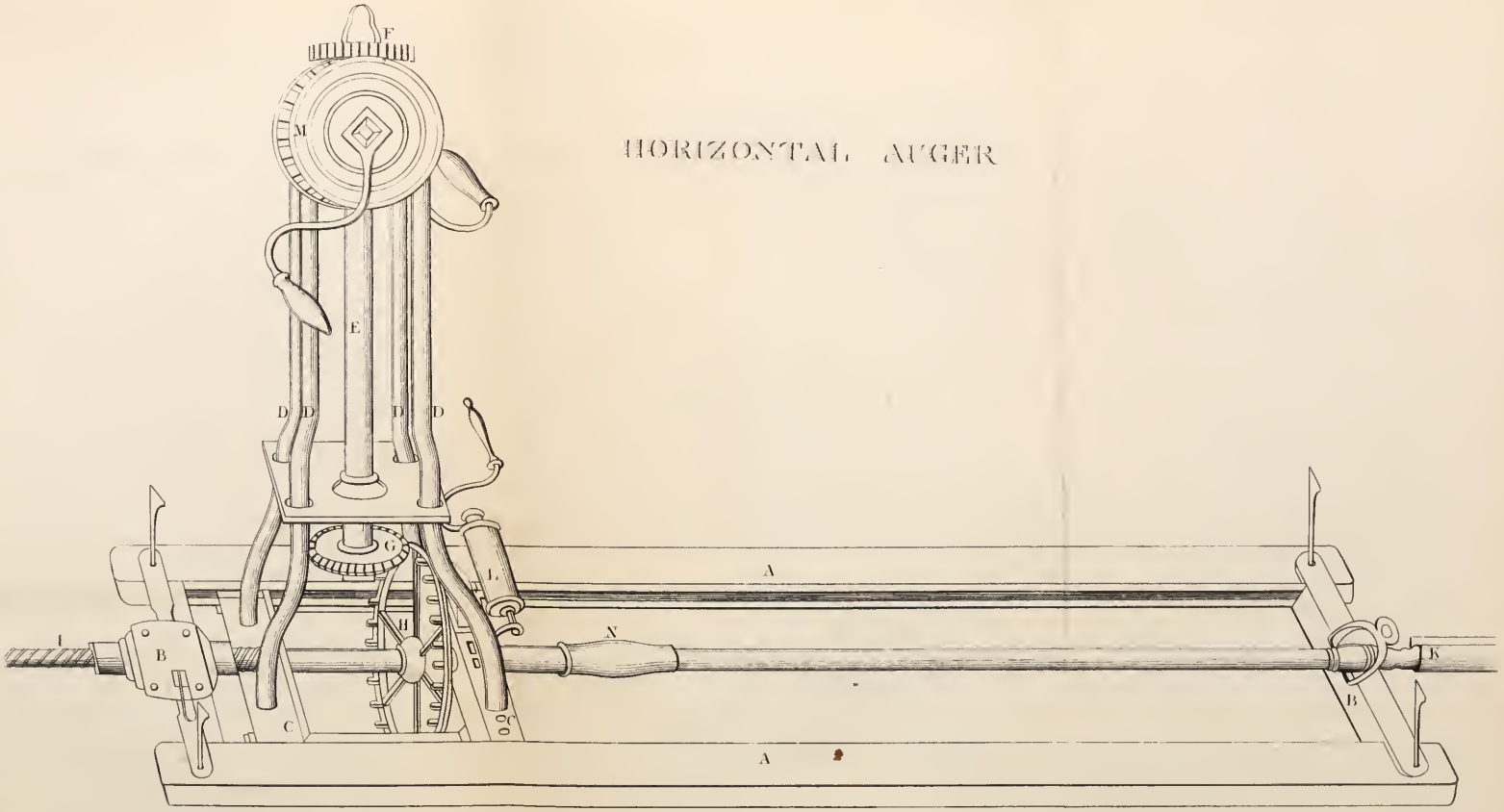


L *Winch & Roller for reversing the Rods.*

M *Two contright or side wheels with 24 cogs each, upon which the two handles are fixed.*

N *Joint for lengthning the Rods.*

HORIZONTAL AUGER



EXPLANATION

AA *Frame groved within 8 Feet 10 Inches.*

BB *Ends of the Frame 2 F. 10 Inches through which the Screw and Auger passes.*

CC *Bottom of the Carriage to which the Uprights are fixed.*

DDDD *Upright Standards 4 F. high.*

E *Spindle 2 Feet 10 Inches long.*

F *Upper Cog with ten teeth.*

G *Lower Cog with 24 teeth.*

H *Main Wheel with 32 Do.*

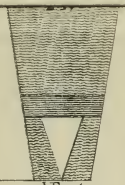
I *Screw 6 Feet 3 Inches.*

K *Auger 6 Feet long and 3½ Inches diameter.*

L *Winch & Roller for reversing the Rods.*

M *Two contright or side wheels with 24 cogs each, upon which the two handles are fixed.*

N *Joint for lengthning the Rods.*



Clay &c.

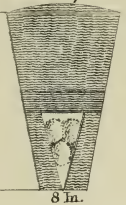
Loose mould or Gravel one foot.

Sod inverted, 6 inches.

Pipe or opening formed by the Draining Spade, 1 foot deep, and 8 inches wide at Shoulders.

1 Foot

No 7.



Gravel or Porous Soil

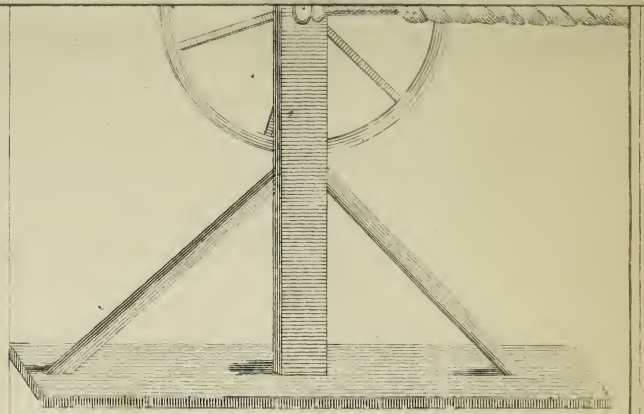
Gravel one foot deep.

Clay trampled in, 6 inches.

Clay

Pipe or opening formed by the Draining Spade, one foot deep, & filled with 3 large Straw Ropes laid longitudinally.

8 In.

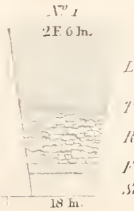


J. Johnstone del.

The depth of the above Drains, is mostly 3 feet, but where the nature of the Soil may admit, the depth may be less, & the materials & mode of filling proportiond accordingly.

N°49

SECTIONS of different hollow or covered DRAINS &c.



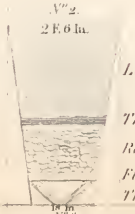
Loose mould thrown in. one Feet.

Thin Sod inverted. 2 inches thick.

Round land Stones. one foot thick.

Flat Stone or cover. 4 inches thick.

Sough or conduit 6 inches square. lined with stone.



Loose mould as above.

Thin sod inverted. Straw, heath, or Rushes.

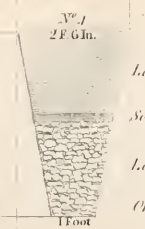
Round land stones. or Faggots of Brush wood.

Flat Stone or cover 4 inches thick.

Triangular opening of 6 or 8 inches.

Land Stones &c. Same as above.

Triangular or coupled opening of 6 or 8 inches.

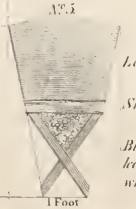


Loose mould or Gravel one Feet.

Sod, Straw, heath or Rushes 4 inches.

Land Stones thrown in promiscuously.

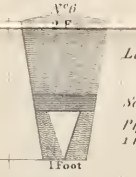
One foot 8 inches thick.



Loose mould thrown in. one feet.

Straw, &c. 6 inches thick.

Brush wood laid longitudinally & suspended by cross billets of wood, leaving the bottom and sides to the height of the cross billets open, which is one foot 6 inches.



Loose mould or Gravel one feet.

Sod inverted. 6 inches.

Pipe or opening formed by the Draining Spade. 1 foot deep, and 8 inches wide at Shoulders.

Gravel one foot deep.

Clay trampled in. 6 inches.

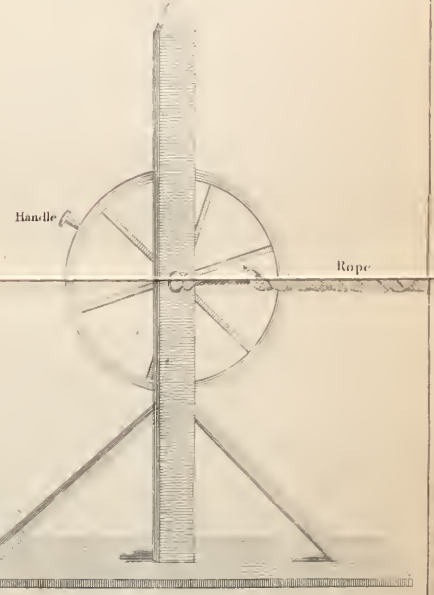
Pipe or opening formed by the Draining Spade. one foot deep, & filled with 3 large Straw Ropes laid longitudinally.

Upper Draining Spade.

Draining Spade. pointed at the end.

Scoop for smoothing and cleaning out the bottom of the Drains.

Engine for twisting Straw into Ropes for laying in the bottom of the Drains.



J. Johnstone del.

The depth of the above Drains. is usually 3 feet. but where the nature of the Soil may admit. the depth may be less. & the materials & mode of filling proportioned accordingly